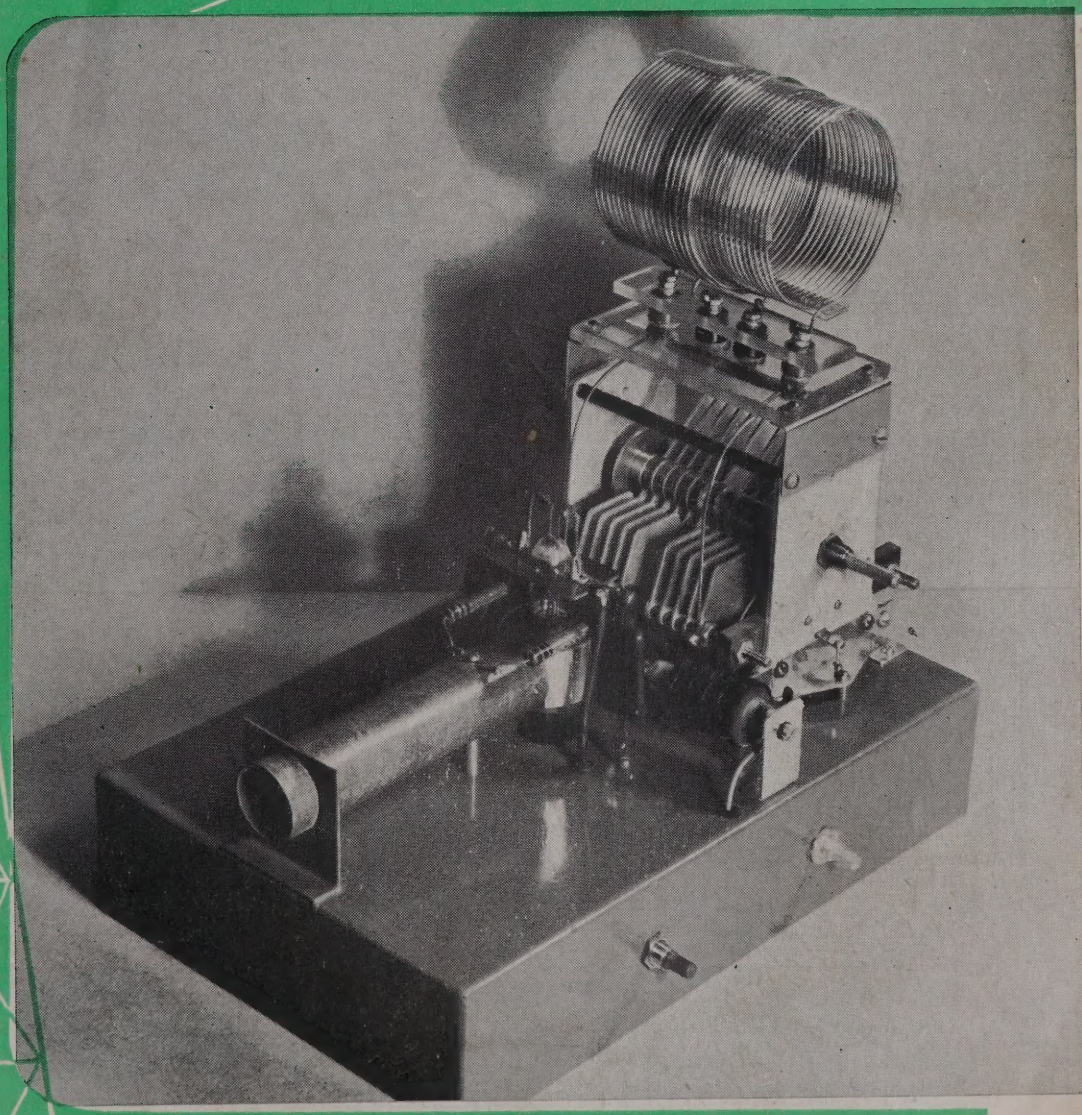
RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND



APRIL 1st, 1952 VOL. 7, NO. 1. 1/10

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Phidelity Transducers

Phidelity Transducers are made in four main types, to suit most requirements.

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Dual-purpose Record/Playback Head. Front and rear gap 0.001 in.

TYPE SE

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TYPE SR

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TYPE SP

Playback Head. Gap 0.00025 in.

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RADIO AND ELECTRONICS

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OUR COVER

This month's photograph illustrates an R.F. power amplifier using a "micropup" war surplus radar tube. A full article about this amplifier will appear next month, and further details will be found on page 47 of this issue.

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WHERE IS OUR TELEVISION?

It is some time now since a committee, charged with making recommendations to the Government about the institution of television broadcasting in this country, tabled its report. Since that time no announcement of any sort has been made, and the radio industry and the public have been left entirely in the dark as to the Government's views and intentions. This, to say the least, is a very unsatisfactory state of affairs. Time and again it has been pointed out, both in these pages and elsewhere, that TV is a matter of the utmost importance and concern to the not inconsiderable radio industry of this country, and that as a direct consequence, the industry is entitled to know, at the earliest possible opportunity, whether or not it is proposed to do anything about it. To make matters worse, the Government has not allowed the advisory committee's report to be published, so that no one knows the views even of those responsible for advising them.

This sort of thing makes one wonder whether bureaucracy will not one day reach a state in which nothing at all can be done, because it will not be permissible to talk about anything until after it is done. Surely there is no secrecy needed about whether or not we are to have television. At least, if there is, there is not the slightest justification for it. No security of any sort could possibly be endangered by allowing the technical advisory committee's report to be published, unless it is the security behind which Cabinet can safely sit and do nothing, while those who are vitally concerned must wait—and wait. It is always possible to reply that TV is a very minor matter compared with things like Britain's economic crisis and the international situation, and that the Government has much more important things to do than discuss it; were sufficiently strong representations made, this is almost certainly the answer that would be received. But that is no answer at all, because if it were, nothing except the most momentous matters would ever be settled. The fact remains that a decision, one way or the other, is badly needed by the radio industry in order that it may make its plans for the future. This is one of those cases where a negative answer is just as important as a positive one, so that even if the Government has no intention of making a decision, it should at least allow to be published the expert advice upon which it ultimately expects to take action. This would give the industry somewhat more to go on than it has at the moment, and would allow an intelligent guess to be made as to the outcome.

We note, too, that the Australian Federal Government has announced that it will not go on with the experimental television station that had been planned, so that the provision of TV services in that country would seem now to be completely in abeyance. This decision is hardly surprising in view of the present economic plight in which Australia finds herself, since to carry on with the project would probably mean spending considerable funds overseas for special equipment, but even so, a very good case could be made out for the continuation of the scheme. What is more, the same arguments as can be brought to bear in relation to Australian television are no less applicable here.

Britain, it will have been observed, has arranged what has been described as a super-priority for several aspects of the defence programme. The far-seeing eye of Mr. Churchill can be discerned in this move, which affects not only the aircraft industry, but also the electronics industry, too, since included on the list of super-priority are developments to the home-defence radar chain, and also the provisioning of the most modern guided missiles, and similar weapons. Lest anyone may say that these things are a far cry from television programmes for the people, let us remind them that had it not been for the advanced state of television technique in Britain prior to the last war, the phenomenal development of radar would certainly not have taken place, nor would there have been those technicians already possessed of a background which enabled them to take the new technical achievements of radar in their stride. And without them, the practical development of the working radar defence system would have been impossible. RADAR, NO LESS THAN FIGHTERS AND THEIR PILOTS, WAS RESPONSIBLE FOR THE SAVING OF THE BRITISH ISLES IN THE BATTLE OF BRITAIN.

This is an object lesson that governments, here and in Australia, should heed, for there is a world-wide shortage of trained technicians in electronics, and the surest way of seeing that more and more radio technicians attain a higher standard than they at present have would be to indoctrinate them in TV techniques. From this point of view, it may well be that the indirect value of TV to Australia and New Zealand could be immeasurably greater than that of economic cheeseparing, crisis or no.

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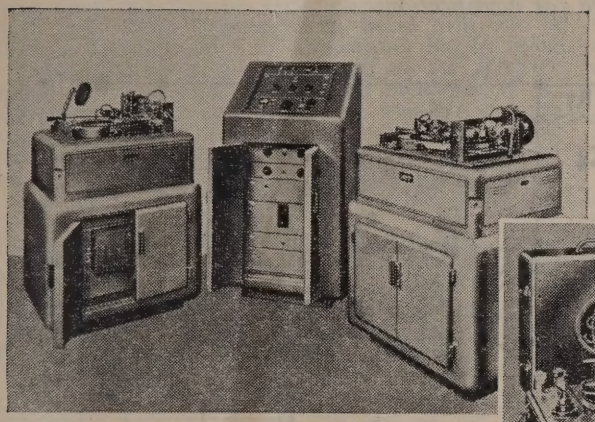

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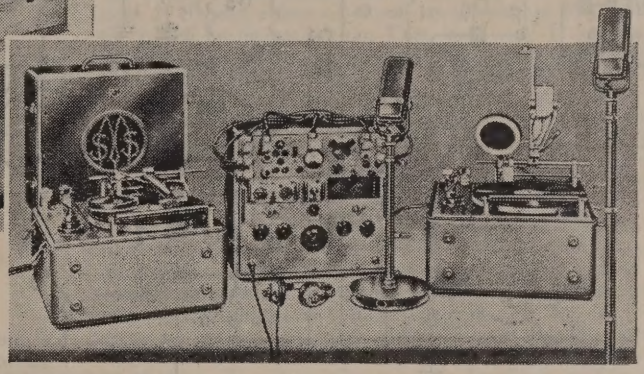

recording equipment . . .

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The illustrations above show:

Left: PROFESSIONAL STUDIO RECORDING EQUIPMENT, providing for continuous or simultaneous recording on two machines at 78 r.p.m. or 33⅓ r.p.m., with radius correction, on discs up to 17¼ in. diameter, from studio or "line," loudspeaker or headphone monitoring, instantaneous check, talk-back to studio, etc. Handsomely finished in enamel, with chromium-plated fittings.

Right: PORTABLE STUDIO EQUIPMENT—Type SP/2/1, designed to make really high-class recordings on discs up to 13 in. in diameter, under practically all conditions of studio, concert-hall, or open-air performance. Two separately controlled microphone inputs, line input and output, and full controls give facilities not previously possible in portable recorders.

TAPE RECORDERS: The M.S.S. type PMR/I Magnetic Tape Recorder is an advanced instrument suitable for professional requirements. Facilities for dubbing direct to disc without extra equipment. Inquiries welcomed. Details on application. We would be pleased to quote against inquiries.

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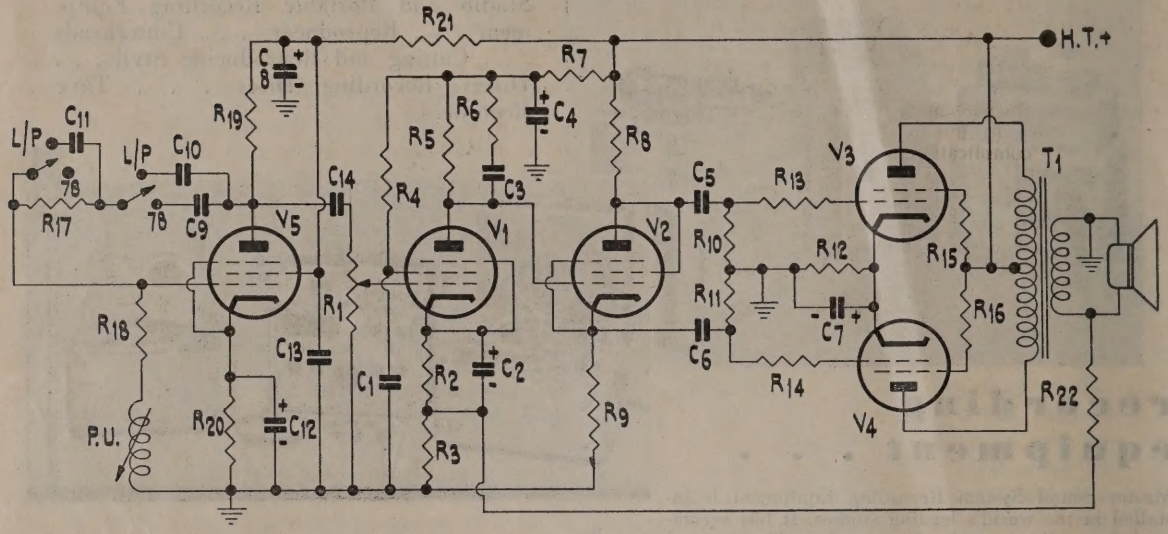
The "78 - L/P Special"

We quite realize that any good amplifier can be used for playing both kinds of record, given suitable pick-up heads and equalization, but with the current interest in L/P records, it was felt that a popular feature with our audio readers would be an amplifier of good quality, specially designed for playing both sorts of record without the need for modification.



COMPONENT LIST

R_1, 500k. pot.
R_2, 2k.
R_8, R_{15}, R_{16}, 25 ohms.
R_4, R_{17}, 470k.
R_5, R_{10}, R_{11}, R_{19}, 220k.
R_6, 10k.
R_7, 40k.
R_8, R_9, 100k.
R_{12}, 250 ohms.
R_{13}, R_{14}, 1k.
R_{18}, R_{21}, 47k.
R_{20}, 1000 ohms.
R_{23} (omitted from diagram) 470k.
Note.—R_{23} is the screen dropping resistor for V_5.
R_{22}, feedback resistor, 400 ohms when speaker impedance is 15 ohms.
C_1, C_{13}, 0.25 μf.
C_2, C_7, C_{12}, 25 μf. 25v. electro.
C_3, 100 μμf.
C_4, C_8, 16 μf. 350v. electro.
C_5, C_6, C_{14}, 0.1 μf.
C_9, 0.001 μf.
C_{10}, 350 μμf.
C_{11}, 300 μμf.
V_1, V_2, V_5, 6AU6.
V_3, V_4, 6V6.
T_1, 10,000 ohms to voice-coil.

IDEAS BEHIND THE DESIGN

There are two basic ideas that have been incorporated in this amplifier that make it different from previous circuits that have appeared in these pages. One is the incorporation of a built-in pre-amplifier stage which makes it suitable, without recourse to separate pre-amplifiers, for playing either type of gramophone record, given one of the modern high-quality light-weight magnetic pick-ups. It may be asked why we have not made it suitable for use with the dual-purpose crystal pick-ups that are readily available today, and the answer is that these pick-ups, with their relatively high output voltage, and their very simple equalization needs hardly require a specially designed amplifier in any case. Elsewhere in this issue will be found some response curves, and remarks on compensation for some of the currently available dual-purpose and dual-head crystal pick-ups, and readers who peruse that article will see immediately what we mean.

In this amplifier, a new and very simple arrangement has been employed for giving the pre-amplifier stage the required response curves for both 78 and L/P records, on the assumption that a magnetic pick-up is to be used that has an approximately theoretical velocity-operated characteristic. In this connection, previous articles in these pages have discussed fairly fully the compensation of this sort of pick-up, and readers are referred to recent past issues if they would like more detailed information on this subject.

However, the means used for providing the necessary equalization in this amplifier are simpler and more economical of parts and valves than many circuits that have previously been published, and this is the first main point about the present design.

The second feature of note is the use of a simple, but very effective method of ensuring that the main amplifier, which uses quite heavy negative feedback, will

not oscillate, even when the most expensive high-fidelity output transformer is *not* used. Many constructors have been put off building feedback amplifiers because they have had trouble with high-frequency oscillation. This is a common fault in such amplifiers, and is most likely to occur when an output transformer differing from the one originally used in the prototype amplifier is incorporated in the builder's copy of it. Unfortunately, it can completely ruin the performance of the amplifier, which immediately becomes much worse than one in which no feedback at all is incorporated. But by using a simple network in the first stage of the amplifier proper, it is possible to guard against oscillation, if not with complete certainty, to a great enough extent to make its occurrence very unlikely indeed. The feature which gives this advantage needs only one resistor and one condenser to put it into practice, and so hardly adds to the complication or expense of the whole outfit.

A third feature that will recommend itself to anyone who wants to build a high-quality amplifier that will not cost the world to build, is that through the use of beam tetrodes, an output of seven or eight watts, with very low distortion, is obtained at much less than the cost of a similar amplifier using triodes in the output stage, to give the same power output. This, of course, arises because of the high power efficiency of tetrodes, which considerably reduces the size and cost of the power supply components, not to mention the fact that 6V6s are very inexpensive tubes themselves.

THE CIRCUIT IN DETAIL

The amplifier proper consists of V_1, V_2, V_3, and V_4, with V_5 as the built-in pre-amplifier valve. Accordingly, the main amplifier will be described first. We have numbered the valves in this way to emphasize the point that this is an excellent amplifier in its own right, quite irrespective of the special features of the pre-amplifier stage. Because of this readers might wish to build it without the additional complication of the pre-amplifier stage, and this can be done simply by omitting the whole circuit of V_5.

V_1 is a pentode-connected 6AU6, and is the main voltage amplifier. With the circuit constants shown, it has an amplification of approximately 200 times. R_2 is its normal cathode resistor, which is bypassed in the ordinary way by a large electrolytic condenser. However, at the lower end of the combination, R_3, of 25 ohms is inserted, and it will be noted that this is unbypassed. This resistor, therefore, causes a slight loss of amplification in V_1, since it introduces a small amount of negative feedback in the first stage itself. This loss has been minimized by making R_3 very small. Its essential purpose is to provide a small impedance across which a negative feedback voltage can be developed, in applying feedback round the whole amplifier. A similar method of applying feedback to the first stage of an amplifier from the output is to leave the cathode resistor entirely unbypassed. In this case, this method was not used, because it would have caused a considerable loss of amplification in V_1 itself. Connected across the plate load resistor of V_1 are the series combination of R_6 and C_3. This simple network is the device, mentioned previously, for preventing high-frequency oscillation. The values are so chosen that they cause the response of V_1 to start rolling off at approximately 12,000 c/sec., so that at about 100 kc/sec., the stage gain has fallen to about one-tenth of the low-frequency gain of the stage. Briefly, the effect is to give the whole amplifier, from the grid of V_1 back to the cathode of the same tube, a gain of less than unity at the frequency where the total phase shift has reached 180°. When this is done, it is impossible for the arrangement to oscillate. Perhaps this point could do with a little more explanation for those who are interested. Those who are not, can skip the next bit, and go on to the next paragraph! In any amplifier, where signal voltage is fed back to the input stage from the output, there is the *possibility* of oscillation. Indeed, when we build an amplifier of this kind, and incorporate special phase-shifting networks, we have made what is usually called a phase-shift oscillator. Now such a device will oscillate only at one frequency, because although there are no tuned circuits present, there is only one frequency at which the conditions for oscillation are fulfilled. These conditions are very simple. They are (1) that the voltage fed back to the input must be in phase with the input voltage, and (2) that the gain round the whole loop must be greater than 1. Should either of these conditions not be fulfilled, there will be no oscillation. That is to say, if there is *no* frequency at which the phase of the fed-back voltage is the same as that of the input voltage, then the circuit cannot oscillate at all, however high the gain. Alternatively, if the gain, at the frequency where the right phase-shift has occurred is less than 1, there will still be no oscillation. Now the cases of the feedback amplifier and the phase-shift oscillator are identical in principle except for two things. In the first case, we do not want the circuit to oscillate, and in the second we do. In the first, therefore, we can do two things to try and prevent oscillation. We can either reduce the gain until the conditions required for oscillation are not satisfied, however much phase-shift there may be, or we can take steps to see that as little phase-shift as possible occurs. The first of these methods is not very satisfactory, because we do not usually want an amplifier with a gain of less than 1. But it usually happens that the frequency at which the phase-shift through the amplifier is 180° is much higher than the highest audio frequency to be amplified and used. Therefore, at those frequencies, we can indulge in as much gain reduction as we like, without affecting the performance of the thing as an A.F. amplifier. Unfortunately, all the simple methods that may be used for reducing the gain at certain frequencies, and not at others, also introduce phase-shift, so that unless we are careful, the phase-shift actually introduced by our gain-reducing circuit may more than catch up with the gain reduction itself, and the result will be a stronger oscillation than before, probably at a lower frequency too! What we really want is a circuit that will reduce gain at high frequencies *without causing any additional phase-shift.*

This is what the combination of R_6 and C_3 actually do, to a first approximation. The combination of these two components with R_5, the plate load resistor of V_1, forms a circuit which has no phase-shift at very low frequencies, none at very high frequencies, and a limited amount at some intermediate frequency. At the same time, it causes no change in gain at low frequencies, but reduces the gain at high frequencies by a fixed amount, determined by the ratio of R_5 to R_6. In this case, this ratio is about 22 to 1, so that the performance of this circuit is somewhat as follows. At frequencies up to 12,000 c/sec., it has no effect on the gain and thus none either on the response of the stage. At this frequency, however, the gain begins to drop, until at about 100 kc/sec. the gain is down by approximately 23 db. on the gain at middle and low frequencies. At a frequency of 35 kc/sec., the phase shift is a maximum, and is approximately 54°. At both lower and higher frequencies, the phase-shift is less than this, so that as long as the shift in the amplifier itself is less than 126°

at 35 kc/sec. there is little likelihood of oscillation occurring at any frequency.

All this explains why the apparently much simpler method of eliminating R_f will not necessarily work as well, since although the gain reduction at the higher frequencies may be greater, the phase-shift at the middle frequencies, say from 30 to 600 kc/sec. might be so high as to allow oscillation to take place notwithstanding.

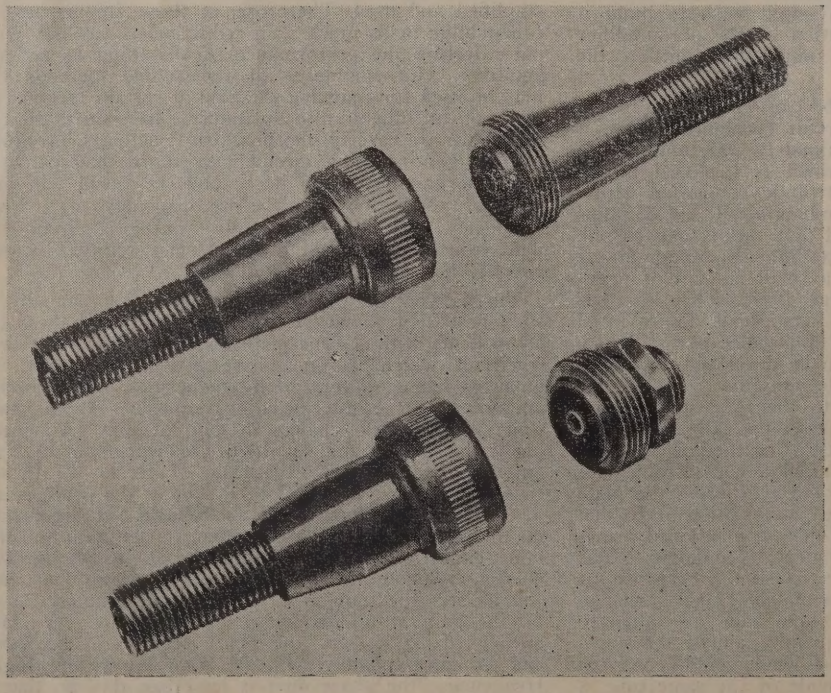
DIRECT-COUPLED PHASE INVERTER

The phase inverter circuit is the common split-load type, slightly modified to allow of direct coupling to the plate of V_1. This scheme has been used before in one of our amplifier cicuits, with great success. All that we have been saying about oscillation in feedback amplifiers can apply at very low frequencies, as well as at high, but in this case, the trouble is rather easier to deal with, since it appears as a common-or-garden "motor-boat," which is easily observed, to say the least! The best way to guard against low-frequency instability in a feedback amplifier is to see that the phase-shift at low frequencies is as small as possible. This can be done by using large time constants in the CR coupling circuits between stages. This means using large coupling condensers in relation to the value of the grid leaks. Of course, low-frequency phase-shift can also occur in the output transformer, and this is one reason why the output transformer should be as good a one as possible. However, if direct coupling is used from one stage to the next, one source of L.F. phase-shift is eliminated altogether, and this eases somewhat the requirement of an output transformer with very little phase-shift at low frequencies. In the experimental amplifier that was built to test the ideas that have been propounded above, it was found that if too much feedback was used, oscillation took place at high frequencies before any L.F. instability was apparent. This indicated that the low-frequency precautions taken were more than adequate, so that if the amplifier is duplicated, with no more than the recommended amount of feedback, trouble from oscillation at any frequency is very unlikely. A margin has been left, too, to take care of variations in component values and in the characteristics of the valves.

In case it might be imagined that the top-cut circuit starting at 12,000 c/sec. might cause the response of the amplifier above this frequency to be down on the mid-band response, it should be pointed out that this is not so. The reason is that the network concerned is inside the feedback loop, so that the overall response is flat to well above 15,000 c/sec., from below 15 c/sec. The total distortion at full output is less than 0.5 per cent., which is good by any standard.

It will be seen that the phase inverter has no cathode bias resistor, since the grid is not returned to cathode through a grid leak. Instead, the D.C. voltage at the plate of V_1 is arranged to be slightly less positive than the voltage that appears at the cathode of V_2. This ensures that the tube is negatively biased in spite of both its cathode and grid being fairly high positive potentials. The component which determines the plate voltage of V_1 is the de-coupling resistor R_7. In this connection it should be noted that the electrolytic condenser C_8 must be a good one, with little leakage, otherwise it will lower the voltage at the plate of V_1, and will tend to over-bias V_2. It would seem at first sight that this would make the value of R_7 quite critical, but in practice it is not so, because the cathode-follower action of V_2 makes it

(Continued on Page 34.)



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Equalizing Crystal Pick-ups for 78 and L/P

In our series of articles covering pick-up equalization for the different records we have so far been dealing mainly with magnetic pick-ups. This article gives some facts and figures on the modern light-weight crystal pick-ups that are currently available.

INTRODUCTION

In previous articles about response compensation for various kinds of record, we have dealt mainly with magnetic pick-ups, and their response to 78 r.p.m. and micro-groove records, but because crystal pick-ups require different treatment altogether, these have been left out of consideration up till now. The present article, we hope, will help to rectify this omission, and will cater for the many people who have purchased modern dual-purpose crystal pick-ups, or dual-speed players and record-changers which already incorporate crystal pick-ups in their make-up.

OPERATION OF CRYSTAL PICK-UPS

This kind of pick-up, unlike the magnetic pick-up, is not a velocity-operated device. That is to say, its output voltage is not proportional to the velocity of movement of the stylus, but to the *amplitude* of the stylus movement. The reason for this is that the voltage developed at the faces of a piezo-electric crystal is proportional to the *pressure* that is applied to the crystal, to cause bending or twisting. The stylus of the pick-up is linked mechanically to the crystal, by a lever, or by a system of levers, so that the extent to which the needle moves from side to side as it follows the record groove determines the pressure brought to bear on the crystal, and hence determines also the voltage output from the crystal. This behaviour is exactly opposite to that of a magnetic armature or a moving coil. In both these cases, the voltage generated is proportional to the velocity with which the stylus moves, and not to its amplitude. Thus, we can expect that whatever the manner in which a record is made, the behaviour of the two types of pick-up will be exactly opposite. The basic characteristic of a 78 r.p.m. record is that above the cross-over frequency it is made with a constant velocity characteristic. That is to say, for a given output level from the cutting head that makes the record, the velocity of the cutting stylus is constant at all frequencies.

Another way of saying the same thing, is that the amplitude of the stylus movement is smaller, the higher the frequency. A little thought will prove that this must be so. For at, say, 2000 cycles, the stylus has to make twice as many side-to-side movements as it does at 1000 cycles. Therefore, if the *speed* of movement is to be the same in both cases, the *distance* travelled at the higher frequency must be only one-half the distance travelled at half the frequency. It is simply a matter of time, speed, and distance. Now since a constant velocity record has a falling groove amplitude as frequency increases, the output of a crystal pick-up must also have a falling amplitude with increase of frequency, because the pick-up output is proportional to amplitude of stylus movement.

It will be remembered that a magnetic pick-up gives a flat response from a conventional record at frequencies above the cross-over frequency. A crystal, then, should give a regularly dropping response from the same kind of record, and it does.

Now below the cross-over frequency, the record is made with a constant amplitude characteristic, so that here, the crystal should have a flat response, whereas the magnetic pick-up has a regularly dropping characteristic in this region.

The upshot of all this is as follows: Where the magnetic's response is flat, the crystal's drops, and where the magnetic's drops, the crystal's is flat, so that entirely different equalizer circuits are needed to make the overall response of record and pick-up flat, in the two cases.

THEORY AND PRACTICE

All the above has pre-supposed that the pick-ups we have been talking about, both magnetic and crystal, are each theoretically perfect in their respective performances. In practice, of course, pick-ups, like everything else, do not always conform to theoretical perfection, so that their response curves are not always what we might expect. .....

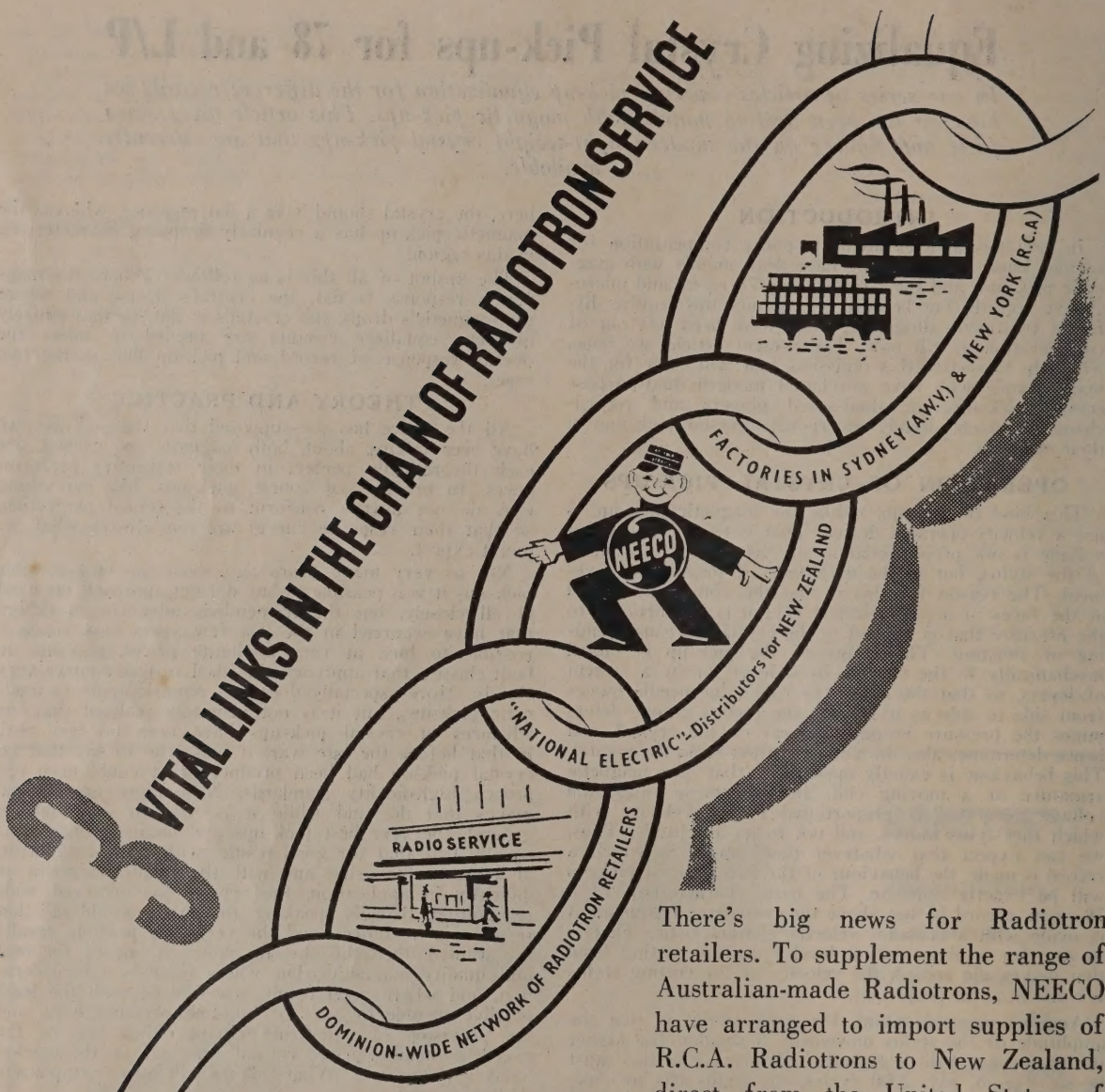
Not so very many years ago, even the best possible pick-ups it was possible to buy did not approach the ideal at all closely, but the tremendous advances in design that have occurred in the last few years have made it possible to buy, at very moderate prices, pick-ups in both classes, that approach the ideal response curve very closely. More especially does this remark apply to magnetic pick-ups, but it is not generally realized that the advances in crystal pick-ups have been no less real, in that before the late war, it was true to say that no crystal pick-up had been produced that could even approach high-fidelity standards. Now there are several makes that do, and while it is safe to say that, in general, the very best pick-ups are magnetic ones, it is equally true that for good results with home equipment, at a reasonable price, and with the smallest amount of difficulty in application, the crystal has achieved wide recognition. Broadly speaking, the writer would say that if price is no object, and the very best possible results are wanted, then the obvious choice is one of the best high-quality magnetics, but where price is a consideration, and where good results are desired with the least possible trouble by way of building pre-amplifiers, and the provision of equalizing circuits, then one of the excellent medium-priced crystals that are on the market today is the answer. What follows will help to emphasize the latter point.

CRYSTAL PICK-UP CHARACTERISTIC

It is possible that the reason why the very best pick-ups today are still magnetic ones, is that it is a relatively simpler matter to control the characteristics of a magnetic pick-up than it is those of a crystal. For this reason, too, it is found that most crystal pick-ups depart somewhat from the theoretical response curve for such things, so that while it is possible to give equalizer circuits for magnetic pick-ups that will be satisfactory for almost any of the high-quality types, the same does not apply quite so well to crystals. Since these tend to depart from theory a bit, there is more variation between the response curves of different makes than there is with magnetics. But this is not to say that crystal pick-ups are not satisfactory, or, as some people sweepingly say, "no good."

(Continued on Page 44.)

3 VITAL LINKS IN THE CHAIN OF RADIOTRON SERVICE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A New Phase-Shift Audio Oscillator Circuit

Most of the circuits previously recommended for the phase-shift type of audio oscillator have several drawbacks from the practical point of view, although exceedingly good performance can be obtained from them if enough care is taken with their design and construction. The new arrangement described here simplifies considerably the problems usually met with, and enables excellent variable-frequency A.F. oscillators to be built with a minimum of trouble and expense.

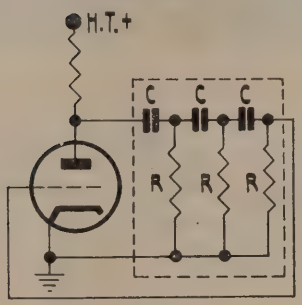

Fig. 1

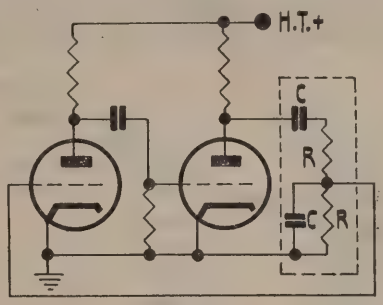

Fig. 2

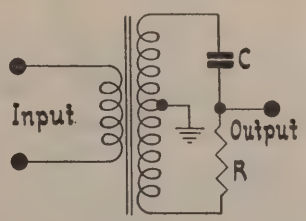

Fig. 3

INTRODUCTION

For serious work with audio amplifiers, one essential piece of test equipment is a good audio oscillator. It is possible to build amplifiers, and audio equipment generally, without one, but proper testing cannot be done unless an audio signal source is available that has at least some of the following features:

(1) The oscillator must cover not only the audio range, from say 20 to 20,000 c/sec., but for many purposes its range must extend considerably on either side of these limits. For example, it is important to test feedback amplifiers at frequencies both higher and lower than those at which it is expected to perform, because its proper operation is largely determined by what it does at frequencies even as high as 100 kc/sec.

(2) Its wave-form must be as perfect as possible. That is to say, harmonic distortion must be kept well below one per cent., and preferably below 0.25 per cent. if possible. This requirement is eased somewhat if the oscillator does not have to be used for distortion measurements with, say, a wave-analyser, and better than 1 per cent. is not difficult to achieve.

(3) It should cover the frequency range in as few steps as possible. The ideal is, of course, to cover the audio range without any range switching at all, but at the present stage of development, the only thing which will do this satisfactorily is the beat-frequency oscillator. Since the usefulness of phase-shift oscillators as a class is largely bound up with their non-possession of many of the design difficulties of beat-oscillators, the restricted frequency range of phase-shift circuits is something that has to be put up with in the meantime, but one of the advantages of the circuits to be presented here is that they enable fewer steps than usual to be made in covering the range.

(4) For ease of use, it is very desirable that the voltage output should be constant, not only over each range, but also as between one range and the next. This can be achieved fairly readily with all phase-shift oscillators, but it is made much easier if the circuit is inherently stable with regard to output amplitude. This again is an advantage of the circuits to be presented here.

(5) Most phase-shift oscillators need to have several circuit elements made simultaneously variable, and because of the limitations of ganged variable resistors, the variable elements are usually condensers. In order to get a satisfactory frequency range, these must be rather large, and introduce insulation and mounting difficulties, because usually, it is not possible to ground one terminal of the variable condenser. The present circuit enables a satisfactory oscillator to be built using a single variable resistor or condenser as the frequency-setting device.

TYPES OF PHASE-SHIFT OSCILLATOR

There are two main types of phase-shift oscillator, both of which have been seen in these pages before. The basic arrangement of Fig. 1 uses three or more CR coupling circuits to give a phase-shift of 180°, so that when the input terminal is fed from the plate of an amplifier valve, and the output is connected back to the control grid of the same valve, the circuit oscillates at the frequency at which the phase-shift is exactly 180°. This method has a number of disadvantages when a variable-frequency oscillator is to be designed round it. In the first place, if a three-stage network is used, the valve circuit must have an amplification of at least 29 times, because the attenuation of the network at the oscillation frequency is 1/29th. This gain is easily achieved at middle and low frequencies, but is too high to be easily obtained at frequencies above 20,000 c/sec. Secondly, if the oscillator is to be variable, the only way of getting a worth-while frequency range is to make all three resistors, or all three condensers simultaneously variable. This is awkward mechanically, especially since both terminals of each condenser are "up in the air." Three-gang condensers are large, and have high capacities from the frame to ground, so that the required frequency range is not easy to get. If the condensers do not have a high maximum capacity, the size of the resistors needed to reach the lower frequencies becomes so great that difficulty is encountered with hum pick-up. Where a reasonably stable frequency calibration is required, using ganged variable resistors is not satisfactory either.

All these points have relegated the arrangement of Fig. 1 to use as a fixed frequency oscillator, or in one

where only minor frequency adjustments are required, and as a result, the circuit of Fig. 2 has become the main one to be used for variable frequency work. It is not intended to go deeply into this circuit, which is sufficiently well-known these days, because the subject of this article is a modification to the arrangement of Fig. 1, whereby many of its disadvantages disappear.

MODIFICATION OF THE FIG. 1 CIRCUIT

In the November 1950 issue of *Wireless World*, W. G. Raistrick describes a method of overcoming many of the shortcomings of the Fig. 1 circuit. As he points out, many of these difficulties are due (a) to the fact that the simple CR phase-shifting circuit cannot produce enough phase-shift per section, and (b) to the high attenuation of the cascaded CR circuits. However, simple phase-shifting circuits exist which enable considerably more shift to be obtained for each network, and which, over wide ranges of phase-shift, produce constant output voltage. The simplest of these is shown in Fig. 3. This circuit is very often used as a method of obtaining two voltages of the same frequency, but differing in phase by a predetermined, but controllable amount. It finds use in oscilloscope circuits for producing circular sweeps, for example. However, for present purposes it possesses one considerable advantage, and one insuperable disadvantage, as it stands. The good point is that phase shifts from 20° to 160° can be obtained, with substantially constant output, so that if it were used in the phase-shifting portion of an oscillator circuit, only two stages of it would be needed instead of three. On the debit side, the fact that it incorporates a transformer prevents it from being used successfully except over a restricted frequency range, unless very expensive transformers were used, and even then, the range would not be as wide as could be wished. It is a matter, then, of suitably modifying this network if it is to be useful for our present purpose. How, then, can this be done?

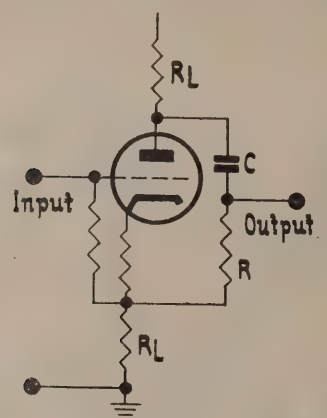

Fig. 4

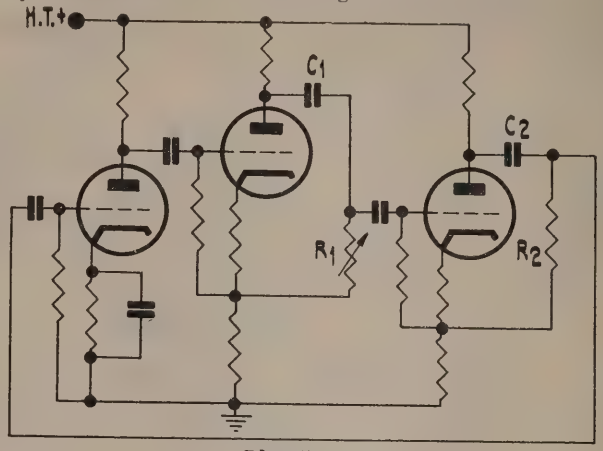

Fig. 5

The important thing to note about Fig. 3 is that the transformer is used only as a means of providing two out-of-phase voltages, to apply them to the phase-shifting circuit proper, which consists only of one resistor and one condenser. Accordingly, we might expect that if any other method of providing the out-of-phase voltages were to be used, the idea would be just as successful. At that rate, the obvious thing to do is to replace the transformer with a phase-splitter using a valve. Theoretically, any valve circuit normally used for phase inversion in audio amplifiers would do, but in practice, one particular one is very much superior to all the rest, and this is the split-load or "concertina" circuit. In Fig. 4 this is shown feeding the CR phase-shifting network, and it can be seen that it merely deputizes for the transformer. To its credit, it may be said that this circuit will work well up to frequencies much higher than the audio range. The accuracy of balance of the two output voltages is limited only by the equality of the plate and cathode load resistors, so that the valve itself can do nothing which unbalances the output voltages, except at frequencies so high that unbalance arises because the capacities from plate to ground and from cathode to ground are not equal. This occurrence can be delayed, almost to frequencies as high as we please, by the simple expedient of reducing the values of the load resistors, and using a valve with a high mutual conductance. Indeed, by carrying this process as far as possible, there is little doubt that satisfactory performance could be had well into the radio frequency range.

Having provided himself in this way with a vastly improved phase-shifting circuit, Raistrick then proceeds to modify the Fig. 1 oscillator circuit in the following way. The circuit of Fig. 4 is placed after the amplifier valve, replacing the first CR circuit in Fig. 1. Then, since the single phase-shift network does not produce quite enough shift to enable oscillation to take place, he adds another shifter, fed from the output of the first, and replacing the second CR circuit in Fig. 1. A maximum shift of 320° is now obtainable, and this is enough, so the third shifting stage is omitted, and the output of the second is fed back to the grid of the amplifier valve.

Now as well as the advantages already mentioned, there is another, which is that our new phase-shift network can easily be made to have an overall loss of only about 1.6 times. This means that the amplifier stage has only to have a gain of this amount in order for the circuit to oscillate. A gain of this magnitude is very much more easily obtained than one of 29, required in Fig. 1, which means that we now have a further reason why the circuit will work at greatly increased frequencies.

The arrangement we have described is illustrated in Fig. 5, and as Raistrick shows mathematically, a range of 10 to 1 in frequency can easily be obtained by making only one circuit element variable. We can use either C_1 or R_3, according to taste, and get as great a tuning range as can be obtained in the Fig. 1 circuit only by using a three-gang variable resistor, or three separate

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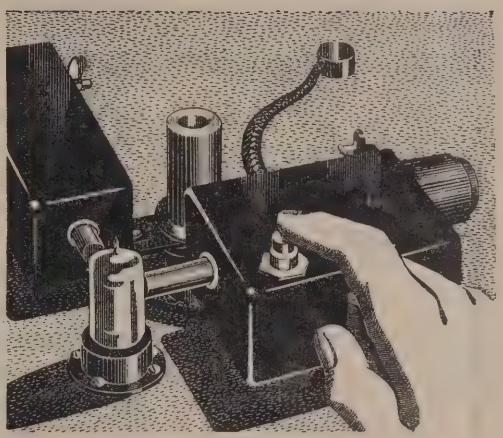

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6.3v. Octal Types	6K7GT	6K8GT	6K7GT	6B8GT	6V6GT	5Y3GT
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condensers, specially ganged together for the purpose.

In designing a practical circuit along these lines there are a number of things that have to be watched, but these do not affect the principles we have been describing at all, and can be regarded as matters of detail that are easily enough coped with as long as their importance is appreciated.

A PRACTICAL OSCILLATOR CIRCUIT

Using valves in the phase-shifting network of the oscillator might make it look as if a practical circuit would end up with a vast number of "bottles," but in practice, it is found that no more are needed than for a workable version of the apparently more simple Fig. 1 circuit.

In Fig. 6 is shown a practical circuit embodying Raistrick's ideas, and arranged so that a single variable resistor gives approximately 10 to 1 frequency variation on each range. In order to prevent output variation through too drastic reduction in the value of R_1, a 10k. limiting resistor is placed in series with the variable resistor, of 1 meg. maximum resistance. The fixed resistor, R_2, of the second phase-shift circuit is made equal to

$$\sqrt{\text{Rmax. Rmin.}}$$

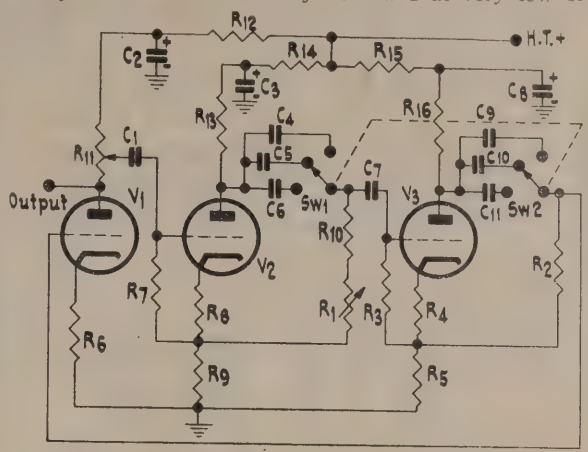
where Rmax. and Rmin. are the maximum and minimum resistance in the variable phase-shift circuit. The phase-shift condensers are made switchable to give different frequency ranges, and the values given on the diagram have been chosen so as to give decade steps, with the lowest range covering 15 to 150 c/sec.

The potentiometer used for R_1 should be an ordinary 1 meg. volume control, which normally has a logarithmic or semi-logarithmic characteristic, and is suitable for spreading out the scale divisions. If a linear control were to be used, the scale would be very cramped at one end, because with only one variable element, the frequency is inversely proportional to the square root of the resistance value.

The plate and cathode load resistors of the phase-splitter valves have been kept low in value so as to lessen the effect of stray capacities from the valve pins to ground, and thus to increase the effective frequency range. The amplifier tube has been provided with an unbypassed cathode resistor, so that the amplification is only about three times. Then, with the phase-shifting circuits fed from a variable tap on the amplifier plate load resistor, a means is provided of adjusting the effective gain of the whole circuit so that it is just oscillating. In this way, distortion can easily be kept at a low figure, less than 1 per cent. being easily achieved. For the valves, with the circuit values shown, 6SN7s are suitable. Two of these would leave one triode section unused, and this could be utilized as a cathode-follower output stage, which would place very little loading on the amplifier valve, and at the same time would give a low-impedance output terminal.

VALUES IN THE PHASE-SHIFT CIRCUITS

As mentioned above, the values have been based on an assumed low frequency limit of 15 c/sec., and a range of 10 to 1 on each step of the switch. Actually, slightly more than this ratio should be obtained, so that if the condensers are switched in ten-to-one steps, continuous coverage is assured. The values shown in the parts list are the theoretical ones, and in practice slightly different values will probably be found to give the specified low-frequency limit. When the condensers for the lowest range have been chosen, then the values for the next highest range should be exactly one-tenth of these. It will be found that for all practical purposes it is possible to calibrate the scale on only one range, and to mark the range switch positions X1, X10, and X100, using the same calibration for all of them. Any differences that may occur will most likely be found at very low frequencies, and perhaps at the extreme high-frequency end too, but if the middle range is used to get the scale calibration, and the condensers for the other two ranges are juggled so that the bottom range agrees with the scale at its top end, and the highest range does the same at its low end, then the result should be perfectly satisfactory for all except applications requiring extreme precision.



COMPONENT LIST

R_2, 50k.
R_3, R_7, 3 meg.
R_4, R_8, 1000 ohms.
R_5, R_9, R_{10}, R_{13}, R_{16}, 5k.
R_6, 600 ohms.
R_{11}, 5k. w.-w. pot.
R_{12}, R_{14}, R_{15}, 10k.
C_1, C_7, 0.05 μf.
C_2, C_3, C_8, 16 μf. electro.
C_4, C_9, 100 $\mu\mu$f.
C_5, C_{10} 0.001 f.
C_6, C_{11} 0.01 μf.
V_1, V_2, V_3, 6J5, or $\frac{1}{2}$6SN7.
H.T.+ up to 300 volts.

Note.—There should be a 0.05 μf. coupling condenser between the plate of V_3 and the grid of V_1. Also, V_1 should have a 3 meg. grid leak.

OTHER POSSIBILITIES

Although the circuit of Fig. 6 has been shown as using one variable resistor for tuning, it would be possible to arrange the tuning in other ways. For instance, it would be possible to make R_1 fixed, and use where more precise holding of the calibration is required, C_1 as the variable element. This could usefully be done since a variable condenser is inherently more stable in its characteristics with time, than a potentiometer. However, the condenser could be used only at the expense of a smaller tuning range on each switch position. For instance, to get a 10:1 ratio, the variable element, be it R or C, must be able to change over a 100:1 ratio. This can readily be achieved with the potentiometer, even after the inclusion of a limiting resistor in series, but to get the same ratio with a variable condenser, we would have to have a condenser with a minimum cap-

acity of only 5 $\mu\mu$f. for a maximum of 500 $\mu\mu$f., and this is hardly possible with present-day components. However, a tuning range of 5½:1 would be possible, so that ranges could be chosen on the basis of multiplying factors of 5, 25, and 125, if desired.

The circuits given here have stressed the fact that the new phase-shifting circuit enables fewer shifting networks, and fewer variable elements to be used, but the improvement can also work the other way. For example, if in the Fig. 6 circuit both the phase-shifting resistors or condensers were simultaneously variable, we would obtain a much wider sweep than previous circuits have been able to get. For example, if both Rs were ganged, then the frequency would be inversely proportional to the value of either (assuming they were both the same in value) so that a theoretical range of 100 to 1 would be obtained. In actual practice, the performance would probably not be quite so good as with the single variable R, because slight errors in matching of the ganged resistors would cause output voltage variations. However, if ganged condensers were used, a range of 30:1 should be readily obtainable, and this is a good deal wider than can be got with existing circuits.

AN INTERESTING POSSIBILITY

An interesting speculation along these lines is that if three phase-shift networks were used, with one element variable in each, then a still wider frequency ratio should be obtainable. Indeed, it might be possible, if not economic, to increase the number of stages still further, and end up with an arrangement that would cover the A.F. range without switching! But without going to ridiculous lengths, it is easy to estimate what the tuning ratio would be if three ganged resistors or condensers were to be used. If all Rs and Cs were made equal, then the frequency would be inversely proportional to the 3/2 power of the resistance or capacity, so that if we ganged up three resistors and made the maximum-to-minimum ratio 100:1, as in Fig. 6, the tuning ratio would be 1000:1. This would mean that it should be possible to get from 20 to 20,000 c/sec. in a single range!

In the case of three condensers, each with a capacity range of 30:1, a frequency range of 165:1 would be obtainable, and with four, a range of 900:1.

However, these possibilities are no more than that, since if such an ambitious project were attempted, it is highly likely that practical difficulties of no mean order would turn up. However, this would appear to offer a useful field for experiment, and in the meantime, the more down-to-earth advantages of the new arrangement should commend themselves to those in need of a good, easily built audio signal source.

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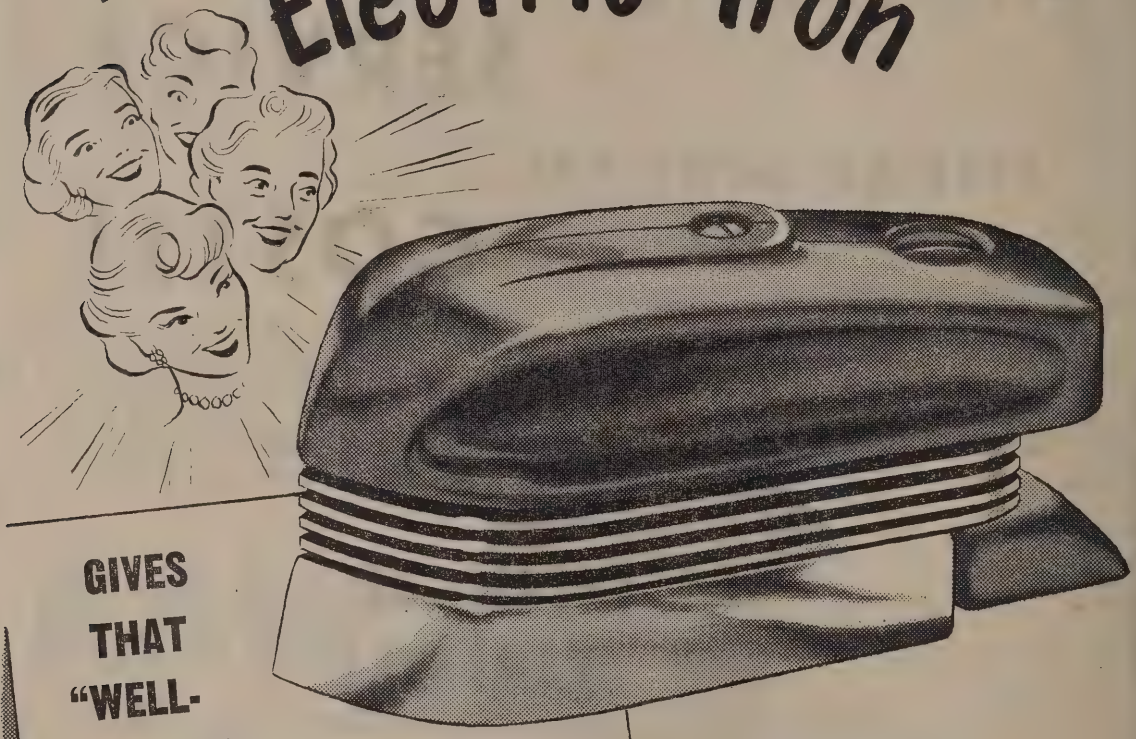

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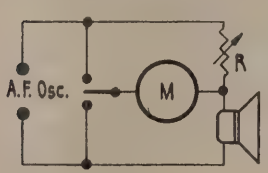

Fig. 1

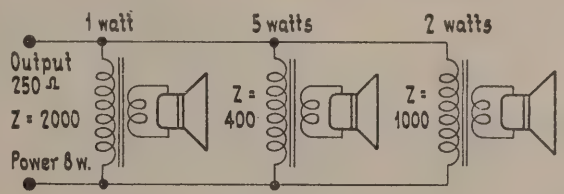

Fig. 2

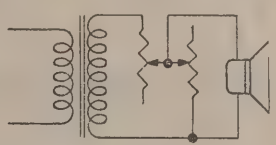
Fig. 3

The correct procedure is most important with high-powered equipment, and very necessary in low-output gear, too, if the best results are to be obtained.

A transformer as is widely known is merely a device (in the audio sense) for transferring power from a high impedance source to a low impedance one or vice versa. Whatever load is put across the secondary will determine the correct value of primary impedance for optimum results. Obviously, we cannot connect a speaker straight on to the plate of the output tube nor is it possible to wind a speaker voice coil with an impedance of several thousand ohms. For the sake of the argumentative, we can say it might conceivably be possible but the result would be something worth seeing and could hardly be calculated to throw the transformer market into a panic!

Now the first consideration in matching is the efficient transference of power from the source to the load. Before this can be done it is necessary to know the recommended load for the output valves, which can readily be obtained from data books; and the speaker load. Where the voice coil impedance of a speaker is not known it can be easily ascertained by the circuit shown in Fig. 1. A non-inductive variable resistance R is connected in series with the voice coil of the speaker in question and the two fed from an audio oscillator. Meter M is a suitable output meter connected between a switch and the junction of the two as shown. Flicking the switch from one side to the other at the same time adjusting the resistance until the meter reading does not change will mean that R is balancing the speaker impedance with pure resistance which can be measured with an ordinary ohm-meter or bridge.

It is customary to measure the impedance at 400 cycles although the same process can be used at other frequencies if considered desirable.

Knowing, as we do now, the primary imepdance and the secondary impedance necessary we can select the correct transformer for the job. The well known formula for turns ratio is expressed as:

$$\frac{\text{Primary turns}}{\text{Secondary turns}} = \sqrt{\frac{\text{Primary impedance}}{\text{Secondary impedance}}}$$

This is not always useful, however, since the number of turns on different transformers is not generally known, but the result can be obtained by measuring voltage ratios which are the same as turns ratios. The formula then becomes:

$$\frac{\text{Primary volts}}{\text{Secondary volts}} = \sqrt{\frac{\text{Primary Z}}{\text{Secondary Z}}}$$

As an example, assume we have a 15-ohm speaker to match to a pair of push-pull tubes having a plate-to-plate impedance of 10,000 ohms. If we have a multi-match transformer we can put 230 volts on the primary and find a pair of taps on the secondary that will give us a voltage corresponding to the correct turns ratio.

Taking the expression

$$\frac{E_1}{E_2} = \sqrt{\frac{Zp}{Zs}}$$

we can fill in the known quantities thus:—

$$\frac{\text{Mains voltage } 230}{E_2} = \sqrt{\frac{\text{10,000 primary}}{\text{15 secondary}}}$$

which becomes

$$\frac{230}{E_2} = 25.8 = 8.9$$

Therefore any pair of taps which will give 8.9 volts with 230 volts applied to the primary gives a correct match. The foregoing assumes, of course, that the transformer is a well-constructed one anyway, and has plenty of primary turns to do the job.

If an exact match is not possible no great harm is done if the difference is not more than 10 per cent. although undistorted power output will suffer accordingly. If a compromise must be accepted it is considered best to operate the valves into a slightly higher impedance rather than a lower one.

In loading a transformer on the secondary side with more than one speaker it is necessary to arrange them in such a way as to present the correct load. Thus four 16-ohm speakers connected in parallel must be fed from a 4-ohm winding when the power will be divided equally amongst them. This arrangement is satisfactory enough when feeding a number of different rooms all requiring about the same sound intensity. Often, however, it is necessary to leave the amplifier output fixed and appor-

tion the sound levels at the speakers themselves. This can be done readily enough by employing speakers with small transformers attached to them and connected in such a way as to absorb power from the line, depending upon the sound intensity needed at any particular point.

Fig. 2 shows an arrangement of three speakers in parallel, each one taking a different amount of power from the line, depending on local requirements.

Assuming the available power output is eight watts and it has been assessed that the speakers would need to deliver in the proportion of 1 to 5 to 2 watts, the transformer impedances can be arrived at in the following manner.

$$\frac{\text{Total power} \times \text{O.P. impedance}}{\text{Power needed at particular point}}$$

$$\text{Therefore speaker No. 1} = \frac{8 \times 250}{1} = 2000 \text{ ohms}$$

$$\text{speaker No. 2} = \frac{8 \times 250}{5} = 400 \text{ ohms}$$

$$\text{speaker No. 3} = \frac{8 \times 250}{2} = 1000 \text{ ohms}$$

In the case where individual control of volume is required on each speaker a local volume control is necessary, and this innocent little statement causes more grief than enough, since most people consider it only necessary to wire a small low-resistance pot. across the voice coil of the speaker. When people in different rooms then start knob twiddling to adjust volume levels the load impedance presented to the amplifier goes into a flat spin with most unpleasant results. The only effective method of controlling volume under these conditions is by means of an L pad which maintains a constant impedance at all settings. A typical arrangement of an L pad is shown in Fig. 3.

In so far as the transmission lines for distributing audio power are concerned they undoubtedly have impedance of their own, but in the main the governing factor is the loading on the amplifier. A pair of lines only become 500 ohms by virtue of being connected to a 500-ohm tap on a transformer. Where they can become critical is in distributing sound over long distances to speakers of low impedance, say, two- or three-ohm voice coils. The impedance of a long line can easily become more than that of the speaker in which case a large proportion of audio power is just wasted along the lines. Conversely, 500-ohm lines although commonly considered to be low impedance are comparatively high and when twisted together over long runs the capacity between the lines can be sufficient to cause serious high frequency loss and consequent dull, lifeless reproduction. The best type of line to run would then seem to be a compromise between the two, neither extreme high nor extreme low impedance; but be that as it may, whatever you do—match 'em right!

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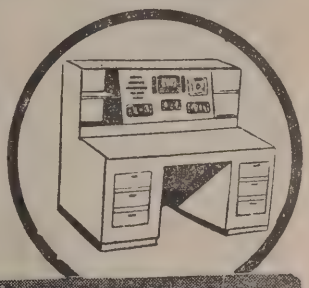

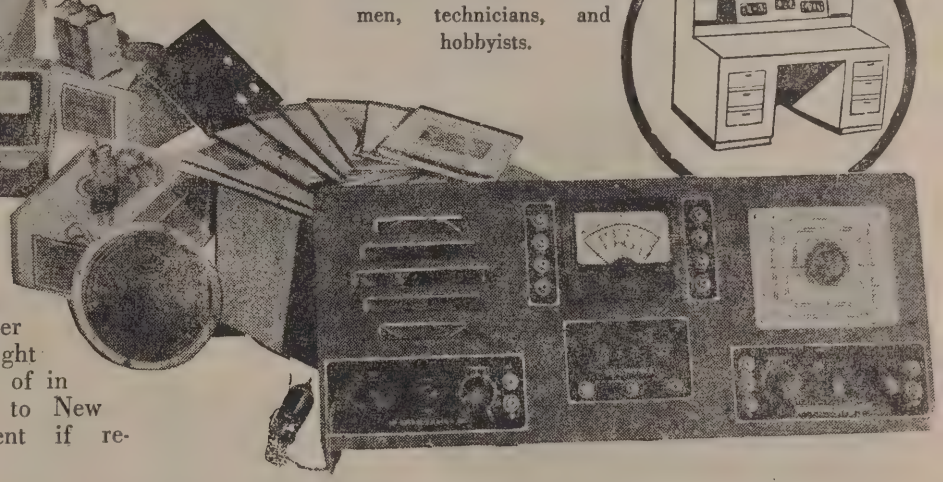

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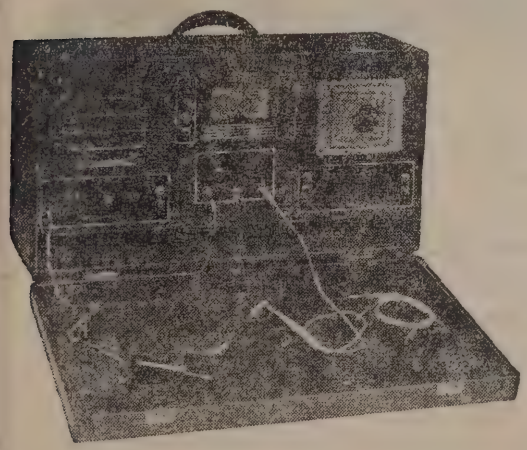

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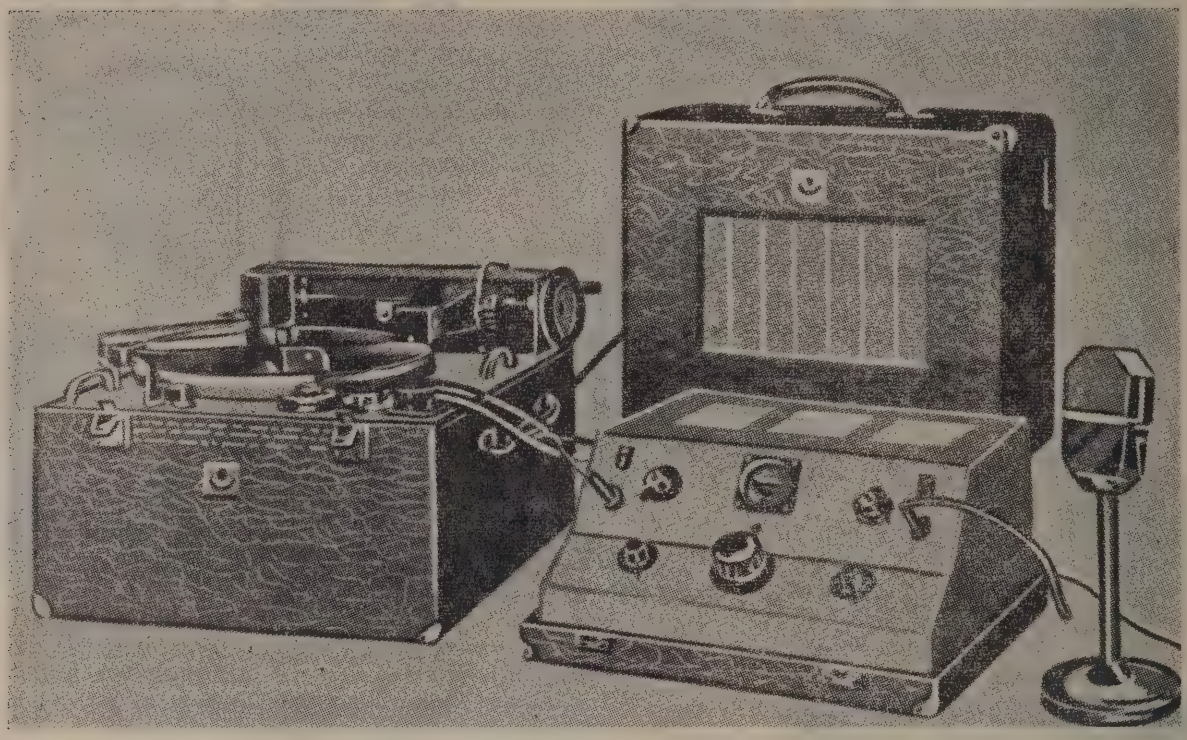

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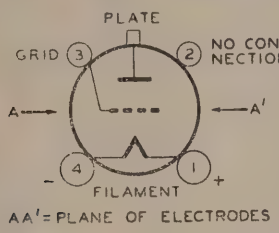
TUBE DATA: 812 Transmitting Triode

The 812 is a new husky transmitting triode with a maximum plate dissipation of 55 watts for class C telegraph service. Because of its high perveance, the tube can be operated at high plate efficiency and low driving power. For example, *two tubes in class C telegraph service (ICAS ratings) may be operated at a plate input of* 450 *watts with the exceptionally low driving power of only* 13 *watts!* The tube may be operated at maximum ratings in R.F. services at frequencies as

Top View of Socket Connections



AA'=PLANE OF ELECTRODES

high as 60 mc/sec. and at reduced ratings as high as 100 mc/sec. In class B modulator service, two 812's are capable of modulating 100 per cent. an R.F. amplifier having an input of 450 watts.

Other features of the 812 include its use of a Zirconium-coated plate which has remarkably high heat-dissipating qualities and which functions as an exceptionally effective getter. The 812 is equipped with the new low-loss "Micanol" base having excellent insulating qualities at high radio frequencies together with low moisture-absorption characteristics. The plate connection of the tube is brought out through a separate seal at the top of the bulb to maintain high insulation.

DUAL RATINGS

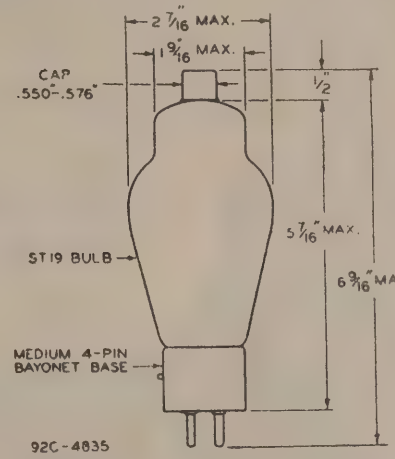
A new system of ratings is used for the 812. Instead of one set of maximum ratings for each service, two are given. These ratings are designated as Continuous Commercial Service (CCS) and Intermittent Commercial and Amateur Service (ICAS). The Continuous Commercial ratings are essentially the equivalent of former Maximum Ratings and are based on providing long tube life and maximum reliability of tube operation. The ratings for Intermittent Commercial and Amateur Service are considerably higher than those for Continuous Commercial Service. They permit the use of much greater power input and provide a relatively large increase in useful power output. Tube life under these conditions, of course, is reduced. Since there are innumerable applications where the design factors of minimum size, light weight, low initial cost, and maximum power output are far more important than extremely long tube life, the transmitter designer may very properly decide that a small tube operated with ICAS ratings better meets his requirements than a larger tube operated with CCS ratings. The new system of dual ratings recognizes these diversified design requirements. The choice of tube operating conditions best suited for any particular application should therefore be based on a careful consideration of all factors.

TENTATIVE CHARACTERISTICS AND RATINGS

Filament voltage (A.C. or D.C.)	6.3	Volts
Filament current	4	Amp.
Amplification Factor	29	
Direct inter-electrode capacitances:		
Grid-plate	5.3	*uuf.*
Grid-filament	5.3	*uuf.*
Plate-filament	0.8	*uuf.*
Bulb	ST-19	
Cap	Medium Metal	
Base	Medium 4-pin "Miconal" Bayonet	

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

	Continuous Commercial Service (CCS)	Intermittent Commercial & Amateur Service (ICAS)	
As A.F. Power Amplifier and Modulator—Class B			
D.C. plate voltage	1250 max.	1500 max.	volts
Max. signal D.C. plate current*	125 max.	125 max.	ma.
Max.-signal plate input*	125 max.	150 max.	watts
Plate dissipation*	40 max.	50 max.	watts
Typical operation:			
Unless otherwise specified, values are for 2 tubes			
D.C. plate voltage	1250	1500	volts
D.C. grid voltage†	—36	—46	volts
Peak A.F. grid-to-grid voltage	175	195	volts
Max.signal D.C. grid current	18	25	ma.
Zero-sig. D.C. plate current	48	42	ma.
Max.-sig. D.C. plate current	200	200	ma.
Load resistance (per tube)	3500	4500	ohms
Effective load resistance (plate-to-plate)	14000	18000	ohms
Max.-sig. driving power (approx.)	6.1	9	watts
Max.-sig. power output (approx.)	175	225	watts



As R.F. Power Amplifier—Class B Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	(CCS)	(ICAS)	
D.C. plate voltage	1250 max.	1500 max.	volts
D.C. plate current	60 max.	60 max.	ma.
Plate input	60 max.	75 max.	watts
Plate dissipation	40 max.	50 max.	watts
Typical operation:			
D.C. plate voltage	1250	1500	volts
D.C. grid voltage†	—35	—45	volts
Peak R.F. grid voltage	46	51	volts
D.C. plate current	48	50	ma.
D.C. grid current (approx.)**	1	1.1	ma.
Driving power (approx.)**‡	1.2	1.5	watts
Power output (approx.)	20	25	watts

As Plate-modulated R.F. Power Amplifier—Class C Telephony

Carrier conditions per tube for use with a maxi. modulation factor of 1.0

	(CCS)	(ICAS)	
D.C. plate voltage	1000 max.	1250 max.	volts
D.C. grid voltage	—200 max.	—200 max.	volts
D.C. plate current	105 max.	125 max.	ma.
D.C. grid current	25 max.	25 max.	ma.
Plate input	105 max.	156 max.	watts
Plate dissipation	27 max.	40 max.	watts
Typical operation:			
D.C. plate voltage	1000	1250	volts
D.C. grid voltage	—100	—125	volts

From a grid resistor of	4000	5000	ohms
Peak R.F. grid voltage	180	245	volts
D.C. plate current	105	125	ma.
D.C. grid current (approx.)**	25	25	ma.
Driving power (approx.)**	4.5	6	watts
Power output (approx.)	82	120	watts

As R.F. Power Amplifier and Oscillator—Class C Telegraphy
Key-down conditions per tube without modulation§

	(CCS)	(ICAS)	
D.C. plate voltage	1250 max.	1500 max.	volts
D.C. grid voltage	—200 max.	—200 max.	volts
D.C. plate current	125 max.	150 max.	ma.
D.C. grid current	35 max.	35 max.	ma.
Plate input	155 max.	225 max.	watts
Plate dissipation	40 max.	55 max.	watts
Typical operation:			
D.C. plate voltage	1250	1500	volts
D.C. grid voltage:			
From a fixed supply of	—125	—175	volts
From a grid resistor of	5000	7000	ohms
From a cathode resistor of	835	1000	ohms
Peak R.F. grid voltage	215	285	volts
D.C. plate current	125	150	ma.
D.C. grid current (aprx.)**	25	25	ma.
Driving power (aprx.)**	5	6.5	watts
Power output (aprx.)	116	170	watts

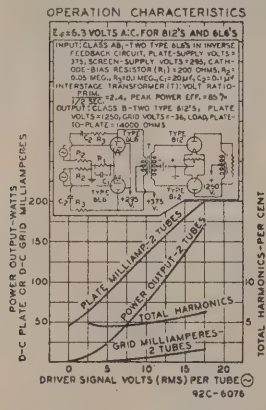
*Averaged over any audio-frequency cycle of sine-wave form.

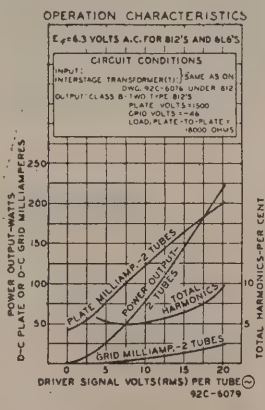
†Grid voltages are given with respect to the mid-point of filament operated on A.C. If D.C. is used, each stated value of grid voltage should be decreased by 3.2 volts and the circuit returns made to the negative end of the filament.

‡At crest of audio-frequency cycle with modulation factor of 1.0.

**Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

§Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exced 115 per cent. of the carrier conditions.





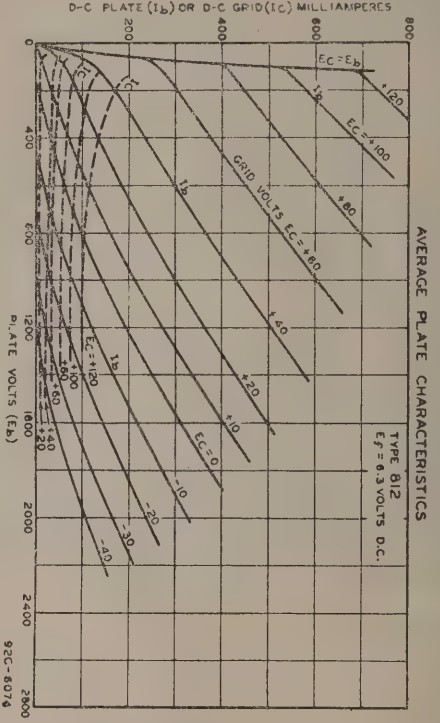
INSTALLATION

The base of the 812 fits the standard 4-contact socket such as the type UR-542A. The socket should be installed to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position, the socket should be mounted with the filament-pin openings one vertically above the other so that the plate will be in a vertical plane (on edge). The plate lead of the tube is connected to a metal cap at the top of the bulb.

The bulb becomes very hot during continuous operation. Therefore, free circulation of air around the tube should be provided.

The filament of the 812 is of the thoriated-tungsten type. The filament voltage should not vary more than ±5 per cent. from the rated value; otherwise, a loss of filament emission may result. It is recommended that, in intermittent service where the average number of daily transmissions is greater than 100, the filament be maintained at 80 per cent. of normal voltage during standby periods. If the number of transmissions is less than 100 per day, the filament power should be removed during standby periods.

The plate of the 812 shows a dull red colour at its maximum plate-dissipation ratings of 50 to 55 watts; it shows no colour at a plate dissipation rating of 40 watts.



Overheating of the 812 by severe overload may decrease its filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device, such as a high-voltage fuse. This device should instantly remove the plate voltage when the D.C. plate current reaches a value 50 per cent. greater than normal.

In order that the maximum ratings given under Characteristics will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltage will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case the circuit adjustments are incorrect. It is advis-

(Continued on Page 27.)

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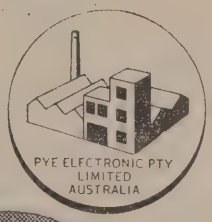

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No. 54: Receiving Single Sideband

We have expended a good deal of time and space over the last several Experimenters in describing the principles, and some of the practice of single-sideband transmission. Enough has been said to enable readers to build and put on the air a single-sideband transmitter, but up till now, the receiving side of the matter has received very little attention. Before we leave the subject, therefore, it is essential that something be written about methods of receiving these transmissions, since the greatest single obstacle to the fuller utilization of S.S.S.C. is probably the presumed difficulty of receiving it properly. We say "presumed" because, as with many other things, once the way is known, the difficulties largely disappear.

METHODS OF S.S.S.C. RECEPTION

There are three methods of receiving a single sideband signal. They vary in cost and complexity, and also in the value of the results that can be obtained from them, but none of them are really difficult to apply. The simplest, and the least satisfactory method requires no additional equipment, since it requires only a normal communications receiver. For this reason, no one can legitimately say that he has not the means wherewith to receive single sideband. All he needs is to know how to operate his existing receiver. The third method requires a quite complex adapter which is used in conjunction with the normal receiver. Briefly, the adapter does exactly the same tricks as the S.S.S.C. generator we have described in these pages, except that it does them backwards, as it were. This sort of adapter gives the best possible results, as it gives a considerable increase in the effective selectivity of the receiver, even if the latter is quite a broad one by modern selectivity standards.

Fortunately, though, the second method, not yet described, gives almost as good results as the "full-scale" method we have been describing, but with a great deal less in the way of additional equipment, and therefore of expense and constructional trouble. This is the method which is the main subject of this month's Experimenter, but before we go on to describe the adapter which we have designed around it, it will be best if we say something about the reception problem generally, so that readers may see just what are the problems involved, and why the simplest method of using a normal set is nowhere as good as could be wished.

THE MAIN PROBLEM

If a single-sideband signal is received on a normal set with the B.F.O. turned off, as might be expected for a 'phone signal, the results do not sound like any noises made by man. The result is complete unintelligibility, because the system of detection used in a conventional receiver is based on the supposition that the signal consists of the speech sidebands together with a carrier. In ordinary detection, we really have a process of frequency changing, in which the R.F. speech components, each of which represents an audio frequency, are made to beat with the carrier frequency to produce difference frequencies, which *are* the audio frequencies originally picked up by the microphone. If no carrier is present, these speech components beat only with each other, to produce rapidly changing audio frequencies which bear no relation at all to the original speech. Thus, if we are to use a conventional detector circuit with S.S.S.C., the carrier must be present, by hook or by crook. Seeing that the carrier is not present in the signal itself, it must be provided by the receiver. This means that an oscillator must be provided, and must be tuned to the exact frequency of the missing carrier. Since practically all our reecivers are superheterodynes, this in turn means that the oscillator must work at the nominal I.F., and that the set must be tuned in such a way that the sidebands are exactly right in frequency in relation to the oscillator. The obvious character for the role of oscillator in this system is the ordinary B.F.O., so this is turned on, and we try tuning once more. This time, as the receiver dial is carefully manipulated, a point is reached at which the unintelligible noises clear up as if by magic, and speech is heard. It is found, though, that unless the frequency of the oscillator with respect to the signal is correct to within about 50 c/sec., the speech is very distorted. Thus, the first and most obvious requirement is an exceedingly stable B.F.O. If this is subject to drift, then to retain intelligibility, the operator is forever retuning either the set or the B.F.O. Luckily, at the low frequency at which most B.F.O.s work, the required short-term stability is not too difficult to achieve, and it is usually found that unless this part of the circuit is defective, there is little difficulty in keeping it "on the nose" once the set has really warmed up. The best method of reading an S.S.S.C. signal, when found, and recognized by means of its unintelligible nature without benefit of B.F.O., is to turn the B.F.O. off until the tuning control has centred the "monkey chatter" in the passband of the receiver. This done, the A.V.C. is turned off, and the B.F.O. on. The latter is then carefully tuned until the right frequency is found, as shown by least distortion on the speech. This done, an improvement will usually be effected by turning the audio gain control full on, and then getting the desired volume by adjusting the R.F. gain control.

WHERE THIS SCHEME LOSES OUT

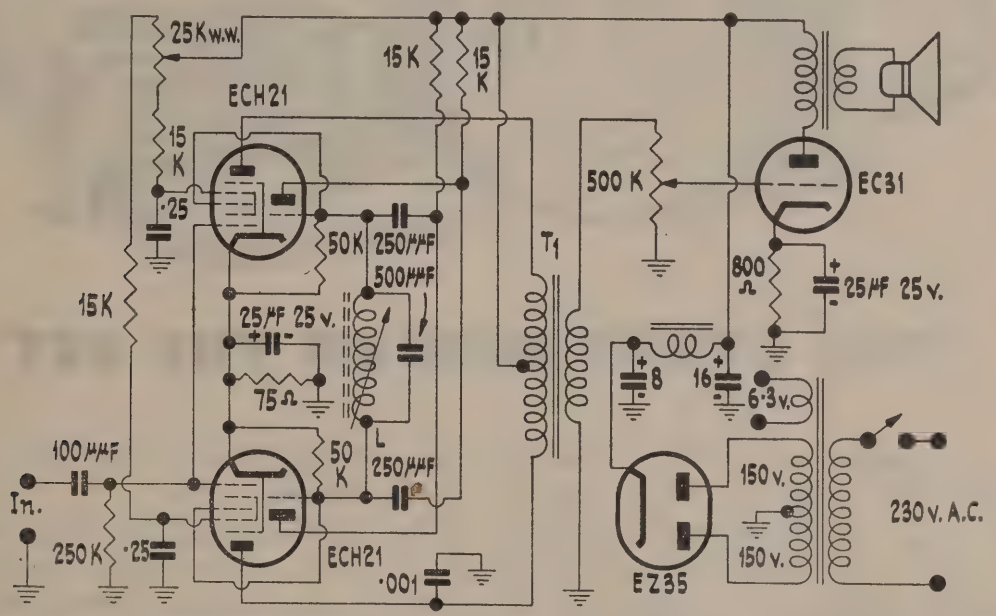
All the above looks very nice and straightforward, and so it is, but there is a nigger in the woodpile. It is the behaviour of the system under conditions of interference from other stations. If a normal A.M. transmission is present at a great enough level, the ordinary detector circuit will cause its modulation to be heard along with the desired signal. This drawback is minimized by using the technique described above, of making the B.F.O. signal to the detector much larger than the I.F. signal, but even so, interfering A.M. transmissions are able to ride through if their strength is great enough. What is required, is a method of detection for the S.S.S.C. signal that does not respond at all to A.M. signals, and

the relatively simple adapter about to be described does just this.

DETECTION BY FREQUENCY CONVERSION

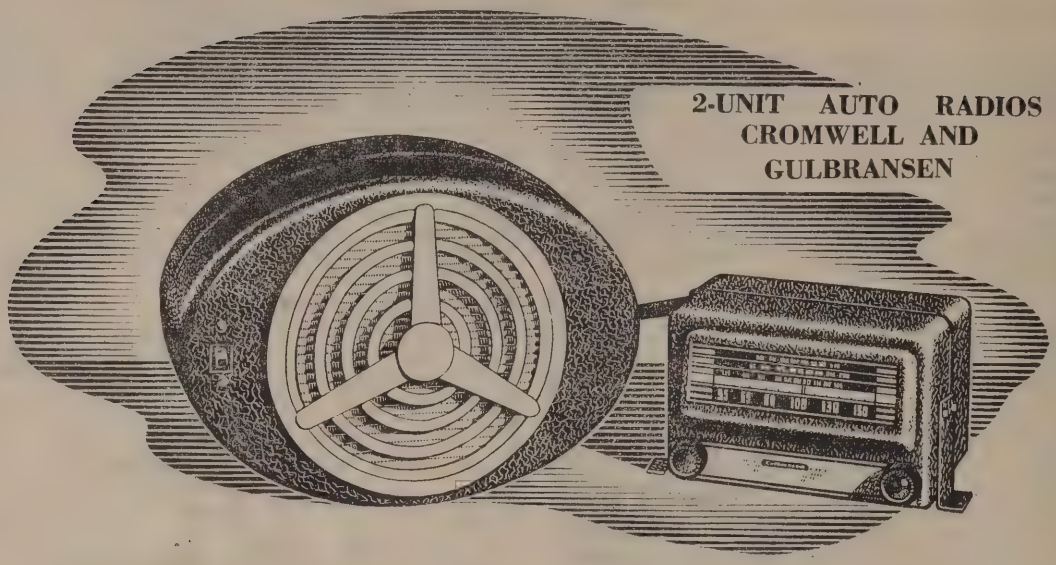
In the detection of an A.M. signal, rectification is essential if the intelligence is to be recovered, but the characteristic of a single-sideband signal is that it can be detected without recourse to rectification. If this is done, then any A.M. signal that may be present at the same time will not be properly detected, and any sound resulting from its presence will not be of an intelligible nature. Because of this, its annoyance value is greatly reduced, since the S.S.S.C. signal is the only intelligible one present, and the brain does not have to "sort out" two different lots of intelligence that are presented to it at the same time.

The principle of the adapter is that it is simply a frequency converter. The single sideband can be looked upon simply as the original speech frequencies, shifted by a process of frequency conversion to a place in the radio frequency spectrum. Consequently it should be possible to recreate the audio frequencies by performing another frequency conversion. For example, if we apply the single sideband to the signal grid of an ordinary frequency changer valve such as a Phiilps ECH35 or an ECH21, and then use the oscillator section of the valve in the usual way, as an oscillator, the hexode or heptode section will, by the normal process of frequency conversion, have present in its plate current, components at audio frequency, and these can be taken off by a suitable output circuit, and applied to an audio amplifier. For example, suppose the signal consists of a single audio tone of 1000 c/sec. The I.F. of the receiver is 455 kc/sec., so that irrespective of the frequency at which the signal was transmitted, the receiver's last I.F. stage will have a single frequency passing through it. This frequency will be either 454 or 456 kc/sec., depending on whether it was the upper or lower sideband that was removed at the transmitting end. The oscillator section of the triode-hexode mixer valve will be working at exactly 455 kc/sec., so that in the valve, sum and difference frequencies will be produced. Let us suppose that the signal is 456 kc/sec. In that case, the frequencies produced in the valve will be 456 + 455 = 911 kc/sec., and 456 — 455 = 1 kc/sec. We bypass the plate of the mixer tube with a condenser, which effectively removes the first of these frequencies, and we put the primary of an audio transformer in series with the plate, so that the second is taken off. It also happens to be the original 1000-cycle tone that was transmitted. Thus, by a frequency-changing process, without any rectification at all, the original modulation has been recovered.



If triode-hexodes were theoreticaly perfect, they would not act as rectifiers at all, but, like all practical valves, they do have a small amount of curvature to their characteristic, and so when large signals, such as are found at the output of an I.F. amplifier, are fed into them, a small amount of rectification does occur. It might seem, therefore, that this fact would make the mixer type of detector as bad as the diode detector for receiving single sideband without interference. Fortunately, this is not so. The rectification effects are not large, but by a simple trick, they can be removed altogether. The trick is again our old friend the balanced modulator. Instead of using a single triode-hexode in the frequency-conversion detector, we use a pair of them in a balanced modulator. The signal grids are paralleled, and receive the I.F. signal from the receiver proper. The plates are connected in push-pull to an audio transformer, while the oscillation injection grids are provided with push-pull oscillator signals. In this way, any rectification that occurs will take place in both tubes at once, but because of the connection, the outputs from the two will cancel in the output transformer, in just the same way as a push-pull amplifier balances out second harmonic distortion. But since the oscillator grids are fed in push-pull, the audio voltages produced in the two valves by frequency conversion add up in the output transformer and are heard.

(To be Concluded.)



THE STORY BEHIND THE SET

An auto-radio-receiver, if high performance is to be achieved without recourse to inconveniently long aerials, involves design problems of special character.

For instance: a particularly high sensitivity is essential to ensure wide-range listening. High sensitivity is largely the concern of the signal circuits and special treatment is required if noise-free amplification is to be realized. The relatively low signal voltages involved demands an efficient transfer in the aerial stage, and overall, a high discrimination against engine ignition fields.

Cromwell and Gulbransen auto-radio receivers are specially designed to provide the highest order of performance under these stringent conditions.

Signal-circuit coils have magnifications of the order of 200 and with zero external fields. Multiple filters provide almost complete isolation from the ignition and electrical system and in most cases, render special devices unnecessary.

The wide public demand for these sets bears eloquent testimony to their performance in practical installations.

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Trade Inquiries to H. W. CLARKE (N.Z.), LTD., 42-46 Cable Street, Wellington

Tube Data

(Continued from Page 22.)

able to use a protective resistance of about 10,000 ohms in series with the plate lead during such adjustments. *The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at the high D.C. plate potential.*

APPLICATION

In class B modulator or audio frequency service, two 812s are used in a balanced circuit, each tube amplifying half the time. The input transformer should be designed to give good frequency response when operated into an open circuit, such as that represented by the grid circuit of the class B stage when the signal amplitude is small. It should also be designed to handle the required input power for a strong signal. The output transformer should be designed so that the resistance load presented by the modulated class C amplifier is reflected as the recommended plate-to-plate load in the class B A.F. stage. Grid bias should be obtained from a battery or other D.C. source of good regulation. Operation curves and circuit for a class B A.F. amplifier with driver are shown.

In class B R.F. service, the 812 may be supplied with bias from a battery, from a rectifier of good regulation, or from a cathode resistor, suitably bypassed for both audio and radio frequencies.

In plate-modulated class C R.F. service, the 812 may be supplied with grid bias from a grid leak, or from a combination of grid leak and fixed supply, or grid leak and cathode resistor. The cathode resistor should be suitably bypassed for both A.F. and R.F. The combination method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In class C R.F. telegraph service, the 812 may be supplied with grid bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. For example, if the 812 is operated at the maximum rated plate voltage of 1,500 volts (ICAS), a fixed bias of at least —45 volts should be used.

The 812 can be operated at maximum ratings in all classes of service at frequencies as high as 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under Characteristics). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 100 mc/sec. for the various services.

Frequency	60	80	100	Mc
Max. permissible percentage of max. rated plate voltage and Plate input:				
Class B telephony	100	90	83	%
Class C telephony, plate-mod.	100	75	60	%
Class C telegraphy	100	75	60	%

When more R.F. power output is required than can be obtained from a single 812, the push-pull or the parallel connection may be used. Two tubes connected in push-pull or in parallel will give approximately twice

(Continued on Page 48.)

The Badge that will protect you and add prestige to your business.

The affairs of the N.Z. Radio Trade will be discussed at the Annual Conference of the N.Z. Radio Traders' Federation to be held in Dunedin on the 14th May.

At this Conference, every dealer who is affiliated through his local Radio Traders' Association has an opportunity of putting forward ideas for consideration in the form of a remit.

The Federation is to serve the Radio Trade, but it is only as effective as individual members make it. First, support your local Association and make it a live body and then it, in turn, can protect your interests.

Remember the N.Z. Radio Traders' Federation is a Federation of the Provincial Associations throughout New Zealand and can be a real help to the Traders.

Support your Federation whose purpose is to protect your interests. Have you an idea which, if put into practice, would help traders as a whole? If so, put it forward for consideration.

Let your voice be heard in discussions of trade affairs vital to your business. The Federation wants your views, too.

Contact your local Association now with any ideas you may have.

This announcement is inserted by the New Zealand Radio Traders' Federation, Headquarters, 8-12 The Terrace, Wellington.

Photo-electric Cell Applications

By the Engineering Department, Aerovox Corporation

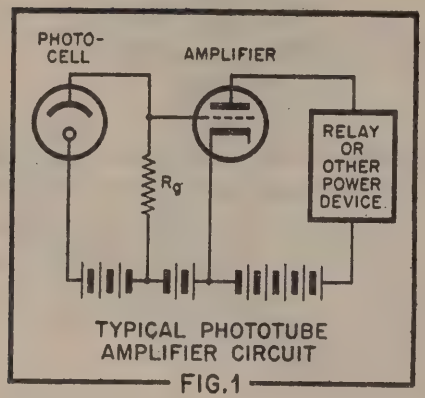


FIG.1

The photo-electric cell, or "electric eye" as it is often referred to, has many applications—from use in burglar alarms and smoke detectors to facsimile, television, and even the measurement of microscopic tissue cells. It is based on a discovery by Hertz in 1887 that emission of electrons can be caused by light striking the surface of certain materials such as sodium and potassium.

Photo-sensitive devices fall into three general classes: (1) *photo-electric* or "photo-tubes", (2) *photo-conductive* cells, and (3) *photo-voltaic* cells. Photo-tubes are those in which impinging light causes emission of electrons from the photo-sensitive surface. Most practical photo-sensitive devices, such as the burglar alarm, automatic counter, door opener, and smoke detector, fall in this category. Photo-conductive cells are those in which the internal resistance varies with the amount of light striking the sensitive surface. These cells are used to operate very sensitive relays and in the measurement of infra-red radiation. Photo-voltaic cells are those which generate an internal E.M.F. upon exposure to light. The ordinary light-intensity meter used in photography employs a photo-voltaic cell connected directly across a low resistance meter.

This article is devoted to some typical applications of the various types of photo-sensitive devices mentioned above.

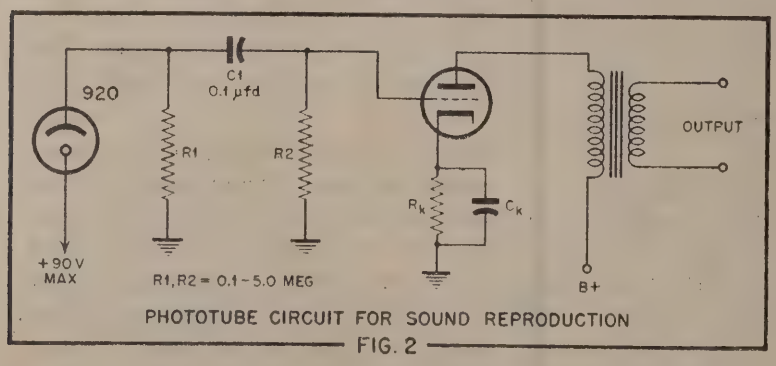


FIG. 2

PHOTO-TUBES

Commercial photo-tubes are essentially diodes contained in glass envelopes very similar to those used for thermionic vacuum tubes. The cathode is usually a large semi-cylindrical surface coated with a photo-emissive material. The anode is a wide lying parallel to the cathode axis. These elements may be enclosed in an evacuated bulb, or one which is gas-filled. The gas tubes ionize when the plate voltage exceeds a certain value and thus pass a larger current than do the high vacuum types. Gas-filled tubes are employed largely in motion picture work where their higher sensitivity reduces the amplification needed. High vacuum photo-tubes are used in light measurement work and in certain relay operating applications. They are less subject to damage due to application of excessive voltage or current, and their sensitivity remains more constant over a period of time.

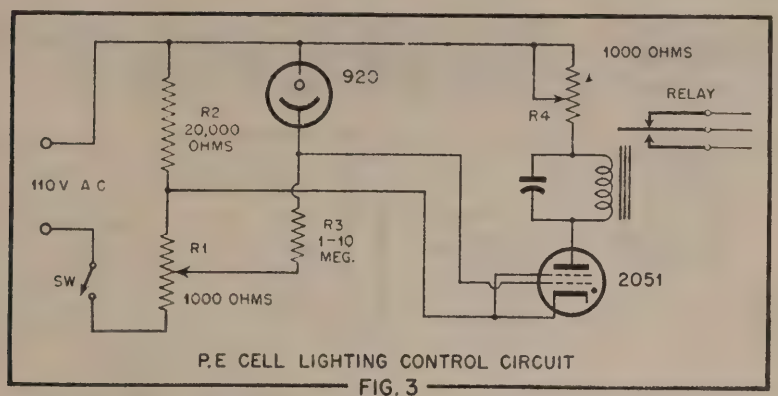
The most common applications of photo-tubes involve the use of associated vacuum tube amplifiers, as in Fig. 1. The tube is coupled to the input of an amplifier by means of a large resistance, Rg. Since the current flow through the cell is of the order of a few microamperes, this resistance should be very high. By proper amplifying circuits, the current in the final output stage of the amplifier may be sufficient to operate a relay or a loudspeaker as in the sound picture industry. See Fig. 2.

Another valuable application of the photo-electric cell is the control of lighting. The tube is used with an amplifier and relay to turn the lighting system on when daylight decreases and off when natural light is again adequate. Fig. 3 illustrates a circuit in which the relay is energized by an increase in light. As long as the illumination on the photo-tube is below a certain value, the 2051 grid potential is below cutoff, and prevents conduction. When illumination rises, grid voltage is made less negative and the tube conducts, closing the relay. The function of R_4 is to keep the current through the 2051 within the tube's maximum rating. Note that this circuit works directly on A.C. line voltage, requiring no D.C. supply.

PHOTO-ELECTRIC COUNTING SYSTEM

The simplest use of the photo-electric tube and relay is that of counting. A beam of light is directed across a conveyor belt into a photo-electric tube which operates a counter. When the beam of light is interrupted by one of the objects to be counted, the change in tube current operates the counter. An interesting circuit of this type is the one-way counter illustrated in Fig. 4. This arrangement records objects passing in one direction, but not in the other.

Suppose an object is passing downward in Fig. 4 so that it obscures photo-tube A and then B. When the light to tube A is interrupted, plate current flows in tube X, opening the contacts of relay X. As the object continues downward, both tubes are obscured and relay Y closes. But since the contacts of X relay are open, no current flows through the Z relay and the counter is



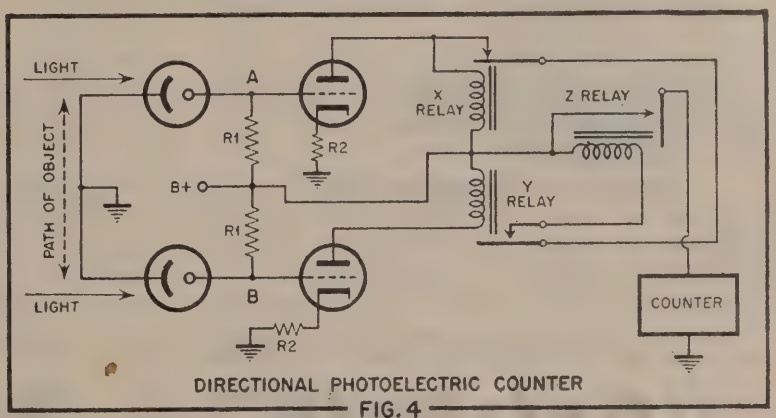
P.E CELL LIGHTING CONTROL CIRCUIT

FIG. 3

flows and the first triode section is blocked. The second section normally conducts current enough to close the relay which opens the solenoid oil valve and allows the flame to burn. Should a flame failure occur, the photo-cell no longer provides blocking voltage to the first section, which then conducts and applies a blocking voltage to the grid of the second triode section. The blocking of current in the second triode opens the relay and closes the oil valve with the simultaneous ringing of an alarm bell.

An even more common kind of industrial safety control is the "light curtain" type of protec-

inoperable. Now suppose that the object passes from B to A. Relay Y is operated when amplifier tube B starts to conduct. Then, when the object obscures both photo-tubes, the current through the amplifier tube associated with photo-tube A passes mainly through the contacts of relays X and Y to operate the Z relay and the counter. Relay X does not operate and its contacts remain closed. Thus, the counter is actuated only by objects passing in the direction from B to A.



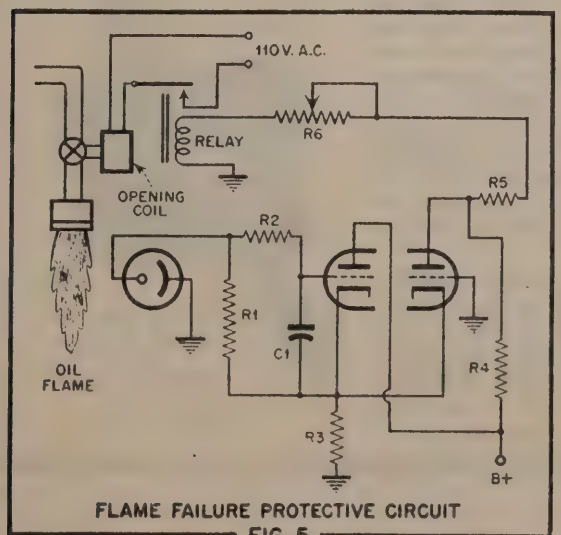
DIRECTIONAL PHOTOELECTRIC COUNTER

FIG. 4

INDUSTRIAL SAFETY CONTROLS

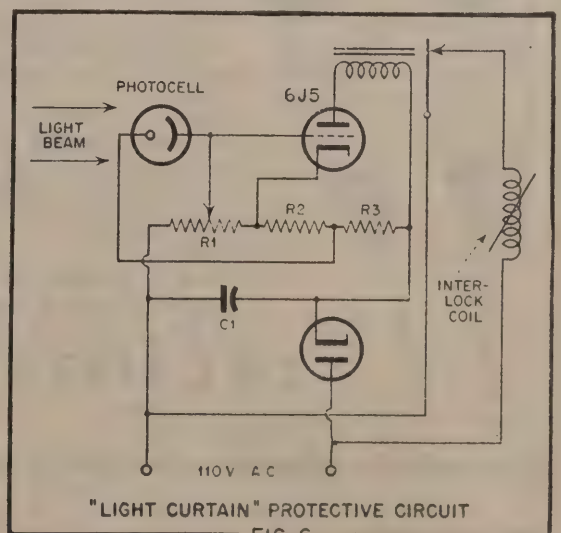
The applications of photo-electric cells to safety devices are very numerous. Some of the more familiar safety controls are the smoke detectors, traffic control, and protective door openers which prevent automatic doors from closing until personnel are clear. Another important protective circuit of this type is the flame-failure detector shown in Fig. 5. This device, intended to safeguard oil furnaces, uses a dual triode as its principal element. When light from the flame is present, photo-current

tive device used to safeguard the operators of heavy machines in this application of photo-electric devices, a light curtain is formed about the area of danger by a series of beam projectors and mirrors, the beam falling ultimately on a set of photo-tubes. If the operator inadvertently reaches into the protected area, one of the beams is interrupted and the machinery is stopped by an interlock operated by the photo-cell relay. Fig. 6 is a typical circuit of this kind. Here the bias potentiometer



FLAME FAILURE PROTECTIVE CIRCUIT

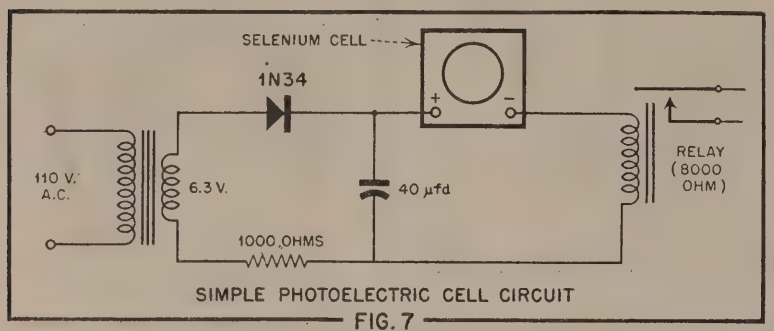
FIG. 5



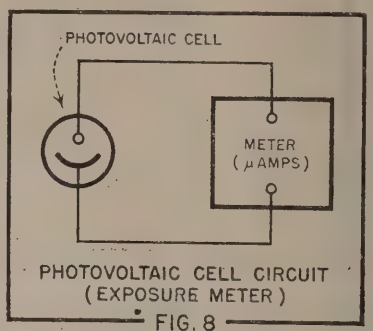
"LIGHT CURTAIN" PROTECTIVE CIRCUIT

FIG. 6

(R_1) is adjusted to cut-off so that the 6J5 does not conduct in the absence of light on the photo-cell cathode. With incident light the photo-current through this bias resistor causes the tube to conduct and operate its load relay which, in turn, operates an interlock which permits the machine to operate. Interruption of the incident light beam causes the 6J5 to cut off and stops or delays the operation of the machine. A safety control of this type is most frequently used with punch presses.



SIMPLE PHOTOELECTRIC CELL CIRCUIT
FIG. 7



PHOTOVOLTAIC CELL CIRCUIT (EXPOSURE METER)
FIG. 8

PHOTO-ELECTRIC GAUGES

Photo-tubes also find many applications in the measurement of time, distance, thickness of materials, etc. A photo-electric device can be made to operate as a micrometer for razor blades, wire, tube stock, and many other materials. A good example is its use in making precision measurements on piston rings. One light beam, directed at a photo-tube, scans the separation of the sample ring and a master. If the sample exceeds the permitted tolerance, a rejection signal is operated. A mechanical shutter cuts off this beam as the piston ring gap is scanned. A second beam, scanning the gap, causes other rejection signals if the gap dimension is under or over tolerances. The entire inspection cycle requires less than 5 seconds.

PHOTO-CONDUCTIVE CELLS

The selenium cell is the most common photo-conductive cell in modern usage. It is usually mounted in a glass container filled with an inert gas. Although used in conjunction with an amplifier in some cases, the

(Continued on Page 48.)

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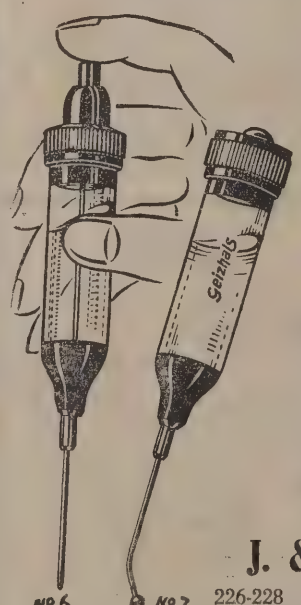
Clean to handle; no oily outside surface. May safely be used on desk, table, or bench.



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Missing or Stolen Radios

The following reports have been received by the N.Z. Radio Traders' Federation, and should any member of the Federation or other reader have any knowledge of the present whereabouts of any of this radio equipment, he it asked to communicate with the nearest police station.

POLICE STATION, BLENHEIM

"Pacemaker" Portable Radio, maroon plastic case, white handle, knobs, silvery finished dials with red pointer, chromium trim on dail surround. Dials swing out and up when catch is released. Type 5150 A.B. Serial No. 97997. Arts and P. Licence Label No. 30769. The set is new and valued at £39 12s. 6d., and it is identifiable by serial and licence numbers.

POLICE STATION, WHANGAREI

Between 10/1/52 and 2/2/52 a radio of the following description was found to be missing from Bond and Bond Ltd., of Whangarei:

A.C./battery Pacemaker Portable Radio, serial No. 98820, Burgundy colour with white plastic handle, dial on hinge and swings upwards when in use; uses type 753 batteries.

POLICE STATION, NAPIER

The radio described hereunder was stolen from Napier on 28th/30th January, 1952:—

Prior 5-valve broadcast radio, bedside type, light green bakelite case, gilt metal band around case, grille on front for speaker, also similar grille at back of case, two tuning knobs on front; serial numbers 7688 and 38387, valued at £18 and identifiable.

Property of Napier Amateur Athletic and Cycling Club.

CRIMINAL INVESTIGATION BRANCH, WELLINGTON

The five undermentioned Philco radios and the three undermentioned Philco radio-gramophones were stolen from Chas. Begg and Co., Ltd., Wellington, between 1/10/51 and 30/1/52. These sets were in their original packing and would possibly require servicing before being put into use:

Radios (5)—Philco Model 622. Six-valve dual-wave, mantel type. Serial Nos. 40946, 40908, 40707, 40742, 40675.

Radio-gramophones (3)—Philco Model 1223. Six-valve dual-wave radio. "Collaro" automatic record changer, mantel model. Serial Nos. 41417, 41352, 41287.

DISTRICT OFFICE, NEW ZEALAND POLICE, INVERCARGILL

Mr. Vernon Taine Russell reported the undermentioned radio stolen from his residence, 39 Swinton Street, Invercargill, on or between 17th December, 1951, and 31st January, 1952.

Description: Philips portable, 5-valve A.C./D.C. latest model; cream coloured case with red carrying handle; chassis numbers 25126 and 5852; valued at £35 and identifiable.

POLICE STATION, UPPER HUTT

Stolen from Hut 95 at the Ministry of Works Camp, Trentham, on Friday, 22nd February, 1952. Unfortunately the serial number of the radio is not ascertainable.

Description: Philco make, battery-electric, about 14 in. x 13 in. x 7 in., faults when on electric power, two control knobs and dial on top of radio plus handle, light varnish wood finish, varnish has been knocked off top of radio.

POLICE STATION, OTOROHANGA

Patricia Thelma Foreman has now supplied details of the set stolen from the Otorohanga District High School on 17/10/51.

Cromwell "Little Jewel" gold and brown coloured portable radio set with plug-in attachment; serial No. 74979; royalty No. 33762, six-inch square base, height twelve inches, valued at £20, identifiable.

CRIMINAL INVESTIGATION BRANCH, WELLINGTON

Reported as stolen by Andrew Barbour Allen, of 40 Ribble Stret, Island Bay, Wellington, from that address between the 24th and 26th December, 1951.

Model 5 "Bristol" Columbus Radio. Serial No. 04124. Wooden veneer surface. Measurements 12 in. x 9 in. x 9 in. Good condition. Valued at £18. Radio identifiable by owner.

CRIMINAL INVESTIGATION BRANCH, CHRISTCHURCH

Stolen from William Stanley Hughes, 172 High Street, Christchurch, and Calder McKay, Ltd., Worcester Street, Christchurch, respectively:

H.M.V., mantel radio, painted cream, size 12 in. x 8 in. x 8 in. wooden case, two knobs, special switch fitted for "off" and "on," round dial set in square, three pieces of sponge rubber stuck on corners of bottom, and a 3-point plug attached to a length of cord. Radio purchased at Mason Struthers, Ltd., Christchurch, eight or nine years ago.

Pacemaker portable radio; black plastic case, white handle and knobs, silver dial, red pointer, chrome trim around dial. Dial swings up when catch is released. Serial No. 98529 and has 10575 pencilled on chassis.

CRIMINAL INVESTIGATION BRANCH, AUCKLAND

Stolen from a house at No. 1 Great South Road, Papatoetoe. Radio is the property of Trevor Alexander King and was stolen between 4.30 p.m. on the 1/3/52 and 9 a.m. on 2/3/52.

Pacemaker battery-electric (A.C.) portable, red leatherette covering, cream coloured dial. Serial No. 83924. Purchased from Atomic Radios Limited, Karangahape Road, Auckland, from 18 months to two years ago.

CRIMINAL INVESTIGATION BRANCH, WELLINGTON

J. R. Howard, Marton. One Mullard radio shortlanded from Wellington on 31/8/51.

One Mullard radio, 5-valve, dual-wave, model 530c, serial number 13841. Licence number 22607, value £18 16s. 4d. Shortlanded from Wellington, 3/8/51 from shipment consigned by C. & A. Odlin to J. R. Howard, Marton.

QUEEN STREET WHARF POLICE STATION, AUCKLAND

Stolen in transit, per rail, between Wellington and Auckland on or about the 30/11/51.

Radio: A.C./battery type, Philips make, serial number 32592/34397, 5-valve, covered with red coloured rexine, bakelite front and back, leather handle on top. Size 12½ in. x 10 in. x 5 in., long narrow shaped dial with two tuning knobs, Philips badge in front. Identifiable and is valued at £21 17s. 8d.

DISTRICT OFFICE, LOWER HUTT

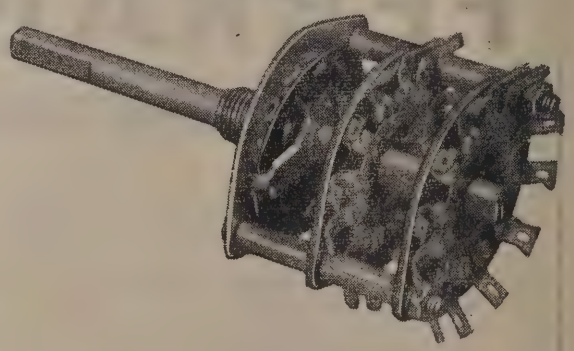
Stolen from Lower Hutt between 1st and 4th February, 1952: Ecko Portable Radio, battery type, five valves, long and short wave, 12 in. x 12 in. x 8 in., with dark blue leatherette covering, white dial with black graduations and pointer set in top of radio, black handle of which forms one half of dial perimeter, three control knobs. Swivel base for direction finding. Batteries flat and require renewal. Probably identifiable, but number not known.

CRIMINAL INVESTIGATION BRANCH, AUCKLAND

Stolen from Mr. Roy Richard Roberts, No. 78 Ridge Road, Mt. Roskill, Auckland, betwen 24th December, 1951, and 5th January, 1952.

One 'Air Line' brand wireless set, 5-valve, home-made wooden walnut polish finished cabinet, measuring approximately 12 in. x 9 in. x 7 in., has streamlined appearance to the rear, telephone type of dial, serial number not known and not ascertainable.

OAK SWITCHES



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Proceedings of the New Zealand Electronics Institute Incorporated.

PROCEEDINGS OF THE INSTITUTE FOR MARCH, 1952

Headquarters News

Following the summer holiday break, arrangements are now in train for the Executive Council to hold its initial Council meeting for 1952. It is hoped that this meeting will take place shortly in Dunedin when consideration will be given to the proposed amendments to the rules.

Branch Activities

Christchurch

Advice has been received that Christchurch branch is recommencing its activities very shortly and members will be advised of full details in due course.

Dunedin

Following the February general meeting, members adjourned to inspect the Air Radio Control system at Taieri Airport, the visit being arranged by the courtesy of Mr. G. Applegarth.

The party were first taken to the control tower where the system of flight control was explained. A point of interest was the ingenious use made of a ZC1 set in the radio system. The method of approach control in low cloud was explained and the anemometer and wind direction instruments were also of interest. The ingenious method used to check the altimeter in the aeroplane with the one in the tower was also a point of attention. The radio control room was next visited, this building also housing the teleprinter units. After explaining in detail the radio systems used, Mr. Applegarth demonstrated the uses of the teletype machines, the complexities of which rather surprised those present. It was interesting to see the weather forecast automatically print itself. The great value of these machines for the instantaneous transmission and receipt of confidential news was plainly evident.

The last building inspected was the transmitter building which is situated some distance from the airport. The complete set-up was explained by Mr. Applegarth, particularly the automatic controls which make constant attendance in this room unnecessary.

This brought the evening to a close and Mr. Symmons proposed a hearty vote of thanks to Mr. Applegarth for his courtesy and consideration in arranging the visit and also for his explanations on points of interest—carried with acclamation.

An appreciation of the kindness of members with cars who provided transport to and from the airport is also worthy of mention.

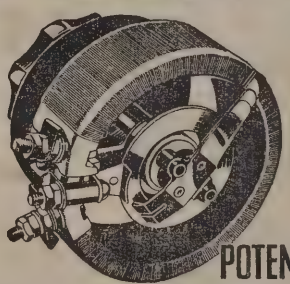
Wellington

The most recent meeting of the Wellington branch was held on Thursday, March 13th, when Mr. A. M. Brown, M.Sc., A.M.I.E.E., who is Chief Radio Engineer to the Civil Aviation Branch, Air Department, gave an address on "Single Sideband Communication in Aircraft."

The subject was of particular interest in view of the fact that Mr. Browne gave details of a developmental programme that is at present being undertaken by the Royal Aircraft Establishment, Farnborough, about which nothing has yet been published in the technical press. The speaker outlined the reasons why single sideband communications equipment would be desirable for use in aircraft, provided that the complexity of the equipment does not make it too heavy for this purpose. The trend of all aricraft communication these days is towards the sole use of telephony, and the ousting of telegraphy, with the delays inherent in its use. In addition, telephony enables an operator to be dispensed with, so that air-ground communication can be carried out directly with the captain of the aircraft. Because of this, the receiving equipment must not require the services of an operator. With ordinary A.M. transmission, this does not cause much difficulty, but with single sideband receivers, it means that considerable trouble and circuitry must be expended in order that the locally generated carrier can have its frequency controlled automatically, and within very fine tolerances. The main reason for wanting to use single sideband lies in the increasing difficulty of using higher transmitter powers on aircraft which are flying at increasingly great heights, thereby incurring greater difficulty with breakdown of aerial

(Concluded on Page 48.)

CRESSALL



TOROIDAL WOUND POTENTIOMETERS

Cressall Toroidal Potentiometers are wound on a heat-resisting ceramic former and are produced in two types: R50 (50 watts) and R100 (100 watts), and also 4 and 6-watt units, both line and insulated spindle. The larger types can be supplied as double or triple-ganged units with simultaneous drive. "Off" position types and slow-motion drive also available. Wide range of Toroidal Wire Wound Potentiometers held in stock; also resistance grids and sliding resistances. Made by the CRESSALL Manufacturing Co., Ltd., England.

Sole New Zealand Agents:

Bradley's Electrical Co., Ltd.

57A Victoria Street, Wellington

The 78 - L/P Special"

(Continued from Page 6.)

much less critical to changes in grid voltage than it would otherwise be, if, for example, its cathode were held at a fixed potential with respect to ground.

The output stage is conventional, with the possible exception that stopper resistors of low value have been included in the control and screen grid circuits. These resistors are not essential, but are merely an insurance against parasitic oscillators, which sometimes afflict beam tetrodes.

VALUE OF THE FEEDBACK RESISTOR

On the parts list, the feedback resistor R_{22} has been shown as 400 ohms, which is the correct value to use when the speaker has an impedance of 15 ohms. If the speaker has a different impedance, the correct value of feedback resistor to use can be worked out from the relation:—

$$R_{22} = 400\sqrt{\frac{Z}{15}}$$

where Z is the actual speaker impedance. For example, should the speaker be one of 7.5 ohms, R_{22} will come down to 283 ohms.

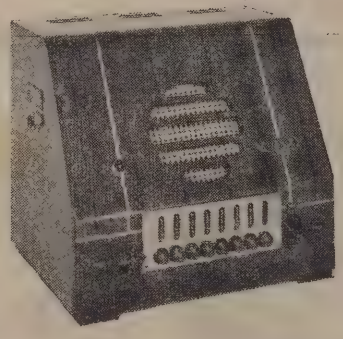
POWER SUPPLY

A suitable power supply would be one delivering 250 volts at 100 ma. This is not an expensive supply, and would have enough capacity to run a radio tuner as well as the amplifier, since the 6V6s draw only 75 ma. at zero input, the current rising very slightly at full output.

THE PRE-AMPLIFIER STAGE

We have left the pre-amplifier stage till last for description since it is rather an unusual arrangement. V_5 is a further pentode amplifier stage, and this too would have a gain of some 200 times were it not that negative feedback has been applied between plate and grid, reducing the amplification to approximately 20 times. Thus, there is a gain reduction in the stage of 10 times, or 20 db. This reduction of gain is not a waste, because it enables the bass boost that is necessary for a magnetic pick-up to be obtained without any *further* loss of gain. That is to say, things are arranged so that the full gain of the tube is realized at, say 50 c/sec., but at middle and high frequencies ,the gain is reduced to 20 times, as indicated above. This is the same thing as saying that the bass response has been boosted by 20 db. This action is brought about by giving a particular response to the part of the circuit which determines the amount of negative feedback. For example, where the gain is required to be higher (viz., at low frequencies) the feedback is arranged to be smaller, and vice versa.

For a start, let us look at the circuit of V_5 as it would be without C_9, C_{10}, or C_{11}. In this case, the upper end of R_{17} would be connected to the plate of V_5 through a large blocking condenser—large enough so that it will not cause any frequency response effects. In this case, the feedback circuit consists of R_{17}, R_{18}, and the pick-up all in series. In the case of magnetic pick-ups of the



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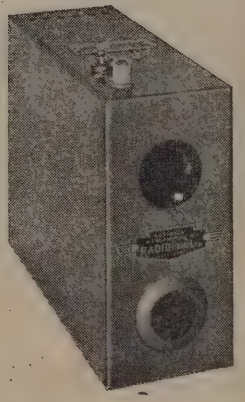


Photo Electric Control Unit

low-output high-quality type, the impedance of the winding is quite low. Indeed, it is much lower than 47k., the value of R_{18}, so that the presence of the pick-up coil in the circuit will not affect the operation of the circuit in any way. With the large blocking condenser in place of C_9 or C_{10}, the response would be flat, and there would be no boost. Now let us replace our imaginary large blocking condenser with C_9, which has a value of only 0.001 μf. In transferring voltage from the plate of V_5 to its grid, this arrangement acts simply as a coupling circuit with much too small a coupling condenser. As a result, the voltage fed back starts to fall off at approximately 300 c/sec., and by the time 50 c/sec. has been reached, the voltage fed back is only about a tenth of that fed back at middle frequencies. Remembering again that where the feedback is smaller, the amplifier gain will be greater, the above explanation shows why, with the 0.001 μf. condenser in circuit, the response of the pre-amplifier stage starts to rise at 300 c/sec., and has risen by something like 10 times, or 20 db., at 50 c/sec. This is the response needed to give a "flat" output from 78 r.p.m. records.

For L/P records, however, the pre-amplifier boost must start at 1000 c/sec., so that the same boost circuit will not do as is used for 78s. However, all that has to be done is to change the value of the condenser, and in the "L/P" position of the selector switch, C_{10}, of 350 $\mu\mu$f. is placed in circuit instead of the 0.001 μf. condenser.

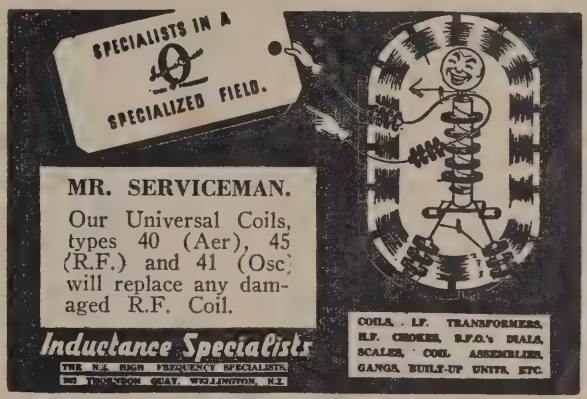
For 78 r.p.m. records, no equalization at all is needed in the frequencies above 300 c/sec., so that the entire feedback circuit for 78 records comprises C_9, R_{17}, and R_{18}. For L/P records, on the other hand, compensation is needed above 1000 c/sec., as well as below it, because these discs have high-frequency pre-emphasis used when they are made. As a result, the pre-amplifier must provide a falling characteristic above 1000 c/sec. This is easily got, in the present instance, by putting a small bypass condenser across R_{17}. This *increases* the feedback at high frequencies, and so decreases the gain, making the over-all response, including the record itself, flat.

Those readers who may already have a perfectly good amplifier, which is not provided with the pre-amplifier circuit needed for the kind of pick-up we have been discussing, will find that the circuit of V_5 will make a simple and excellent additional stage, to enable them to use one of the later magnetic pick-ups .

HUM PICK-UP

When building this circuit in its entirety, it should be remembered that the over-all gain is rather higher than that of ordinary amplifiers, used with high-output pick-ups. Consequently, a little more care than usual is necessary to ensure that the hum level is not excessive. For instance, on no account should a single wire be run for the heater circuit, with one side of each heater grounded. This causes large 50-cycle currents to flow in the chassis, and is just asking for hum to be induced in the input circuit. Two wires should be run to every heater, and the heater circuit should be earthed at only one point. This point should be one of the heater pins of V_5. Also, the input socket, to which the pick-up leads are taken, should be as close as possible to the grid pin of V_5. Preferably, it should have two insulated connections instead of the more usual one, so that both pick-up leads are separately terminated. Then a wire is taken from one of them to the earth-point of the heater circuit. This prevents even the smallest piece of chassis from being part of the grid circuit of V_5, provided the cathode resistor and condenser of this valve are also earthed at the same spot. Of course, the pick-up leads should also be shielded with flexible braid, and this can be earthed by the external metal of the input plug in the ordinary way.

Should the hum still be found to be too great (but this is unlikely) the old trick should be tried of centre-tapping the heater circuit. If this is done with a potentiometer of 100 ohms or so, it should be mounted close to V_5, and the moving arm earthed at the same point as the pick-up lead and the cathode resistor and condenser of V_5. When the pot. is adjusted for minimum hum, the bit that is left should be less than when one side of the heater winding is earthed.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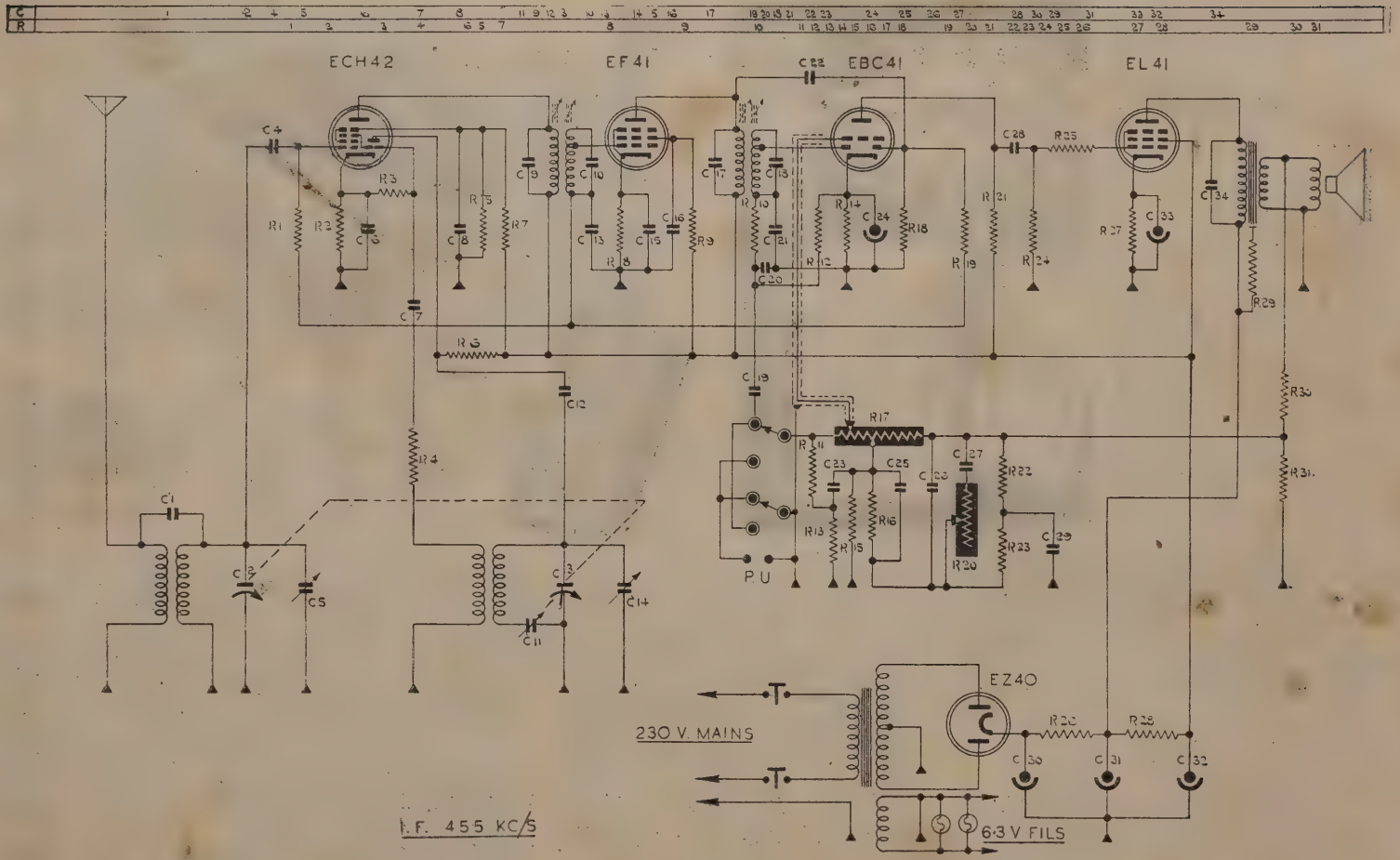

C1	4.7 mmfd. ceramic	C18	I.F. trimmer	R1	1 megohm ½ watt carbon	R16	250,000 ohms ½ watt carbon
C2	12-496 mmfd. } Gang tuning	C19	.01 mfd. 500 v. minicap	R2	220 ohms ½ watt carbon	R17	2.65 megohms volume control
C3	12-496 mmfd. } condenser	C20	100 mmfd. } diode filter	R3	56,000 ohms ½ watt carbon	R18	1 megohm ½ watt carbon
C4	150 mmfd. ceramic	C21	100 mmfd. }	R4	3,000 ohms ½ watt carbon	R19	1 megohm ½ watt carbon
C5	3-30 mmfd. air trimmer	C22	10 mmfd. ceramic	R5	47,000 ohms ½ watt carbon	R20	.5 megohm tone control with switch
C6	.05 mfd. 400 v. paper	C23	400 mmfd. mica	R6	30,000 ohms ½ watt carbon	R21	150,000 ohms ½ watt carbon
C7	56 mmfd. ceramic	C24	25 mfd. 25 v. electrolytic	R7	25,000 ohms ½ watt carbon	R22	6,000 ohms ½ watt carbon
C8	.01 mfd. 500 v. minicap	C25	.02 mfd. 400 v. paper	R8	390 ohms 1/3 watt carbon	R23	47,000 ohms ½ watt carbon
C9	I.F. trimmer	C26	400 mmfd. mica	R9	100,000 ohms ½ watt carbon	R24	470,000 ohms ½ watt carbon
C10	I.F. trimmer	C27	.01 mfd. 400 v. paper	R10	47,000 ohms ½ watt carbon diode filter	R25	100,000 ohms 1/3 watt carbon
C11	150-750 mmfd. padder	C28	.01 mfd. 500 v. paper	R11	300,000 ohms 1/3 watt carbon	R26	370,000 ohms 3 watt carbon
C12	150 mmfd. ceramic	C29	.01 mfd. 400 v. paper	R12	250,000 ohms ½ watt carbon	R27	150 ohms 1 watt carbon
C13	.05 mfd. 400 v. paper	C30	40 mfd. 350 v. } triple electrolytic	R13	68,000 ohms 1/3 watt carbon	R28	1,500 ohms ½ watt carbon
C14	3-30 mmfd. air trimmer	C31	40 mfd. 350 v. }	R14	1,500 ohms ½ watt carbon	R30	330 ohms ½ watt carbon
C15	.05 mfd. 400 v. paper	C32	20 mfd. 350 v. } electrolytic	R15	68,000 ohms 1/3 watt carbon	R31	27 ohms ½ watt carbon
C16	.01 mfd. 400 v. paper	C33	25 mfd. 25 v. electrolytic				
C17	I.F. trimmer	C34	.0047 mfd. 400 v. paper				

Letters to the Editor

Sir,—Your February issue contains a letter of trenchant criticism of my article "A Flexible Test Instrument," and its writer appears to consider that I have ". . . perpetrated a heresy that he cannot permit to pass without the strongest expression of protest," in so far as I have failed to expend space on pæans of praise for negative feedback.

His lofty disapproval of my article and the ridicule that he pours on the instrument itself, lead me to suspect that he is so hypnotized by the advantages of negative feedback that he is blind to the purpose for which the instrument was built. My further suspicion is that he is too impractical to be one of the harried radio servicemen to whom this simple instrument is already proving itself a boon.

If your correspondent "Feedback" has read your November issue—as he must have done, for he would hardly presume to criticize an incomplete article—he must realize that the instrument is a simplification to assist general servicing in modern cramped situations, and that it is not a laboratory instrument, any more than is the usual serviceman's multimeter.

However, nobody will gainsay "Feedback's right to load up his car or van with an infinite baffle or to hamper his movements with moving coil headphones; we will even stand by to applaud him when he has assembled all this gear along with his V.T.V.M. and his test oscillator in Mrs. Whosit's sitting-room to render first aid to her 1935 midget with its 4-inch speaker. Perhaps we may point out to him what a really worthwhile addition would be the inclusion of a variable oscillator in conjunction with a double beam oscilloscope.

In conclusion, may I add that, in my humble opinion at least, it ill becomes a person of "Feedback's erudition to shelter behind a pseudonym while he condemns so forthrightly an article published under its author's name.

C. D. COOK.

* * *

Sir,—Your correspondent "Feedback" gives me the opportunity to ride my favourite hobby-horse, even at the risk of sticking my neck out.

May I say that I, for one, welcomed the article on "A Flexible Test Instrument" for what it is—a useful and convenient instrument for the busy serviceman.

Why won't these back-room boys play with their slide rules and mathematics in a quiet secluded spot, and leave us to our own job—servicing designed equipment with a minimum expenditure of time, capital, and material?

Feedback, indeed? One may as well dose a patient with laxatives to cure constipation, instead of correcting the diet. Feedback is the soft-pedal for the "more watts —less drive, more gain—fewer stages" boogie—a hit tune with the modern back-room boys. And what does it do? Firstly, it pre-supposes sufficient gain to throw away, and secondly it makes the modern beam-tetrode more closely approach the husky he-man triode. It helps to correct imperfectly-designed output transformers and the like, and incidentally reduces a lot of distortion—quite a pile of which wouldn't be there if it wasn't for the modern tendency for super-duper tubes with astronomical gain and the complex controls that go with them to make them sit down.

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45 ohm	50 ohm	70 ohm	100/110
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AS.93.M.	PT.9.M	PT.11.M.	AS.91.M.
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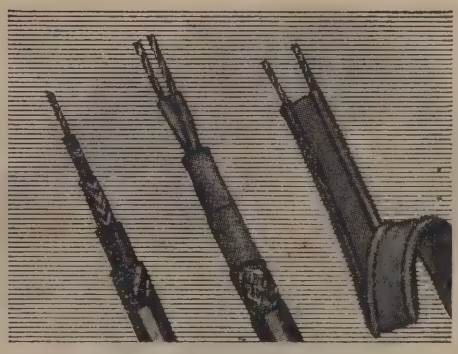
BALANCED TWIN (Screened)

BA.24.PSM. BA.3.PSM.
K.12.SM.



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All of which completely violates the first principle of reliability—simplicity. A busy serviceman has not the time to waste servicing his own instruments. Even the simple feedback circuits are liable to apply so much correction in the wrong places as in the right—making the result like leaving the pancake-rising out. This doesn't upset the back-room boys. They merely add a few more components in the way of resonant circuits—and are lucky if they don't achieve regeneration at one frequency due to phase-shift.

"Feedback" would do well to realize that this is a workshop instrument—not for laboratory use. What on earth is the sense of sacrificing portability, simplicity, and reliability to achieve an instrument that has a better quality than the equipment under test?

Eight-inch speakers in a tin box may not be the criterion of audio faithfulness—but at least they are portable. I envisage Feedback's design as requiring two strong men and a truck to move. True, the headphones would be a nice answer—in theory; but, if he wants to use headphones for testing live equipment, or while testing live equipment, I would suggest his personal affairs be put in order first. Personally, I prefer a safer method of working.

To his last query, I'd plump for the answer that it would add more gear still, and for the job it was designed to do, it is unnecessary.

Having stuck my neck out, I'm quite willing to wait for the inevitable axe, but I would caution all "young squirts" (apologies to "Q.S.T."), to learn the lessons of the early struggles in radio—make things as simple as possible, and get the best out of the least before adding extras to compensate for faults.

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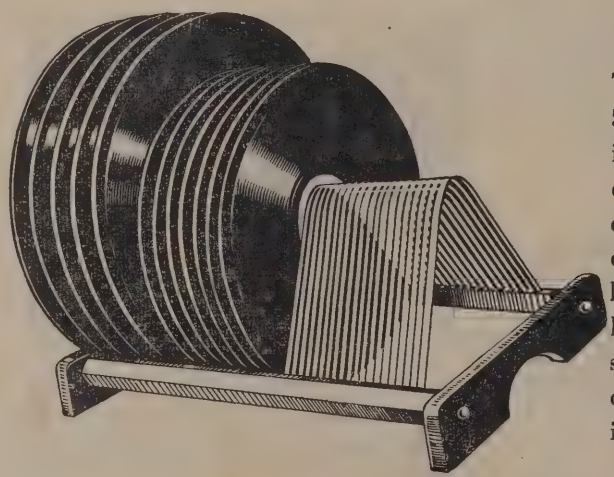

The ideal Record Storage Rack for up to 50 records, 10 in. or 12 in. Each division is individually numbered, and every record can be found at a glance. Numbered Index-cards and Label-stickers are supplied with each "PLATTERRACK". The records are held in place in the "PLATTERRACK" between velvety, rayon covered resilient steel wires, and the records rest on silk cording. Plastic dust-covers are available if required.

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Trade Winds

The Annual Meeting of the New Zealand Radio Traders' Federation will be held at Dunedin on Wednesday, 14th May, 1952.

* * *

Recent appointments to the Industrial Advisory Council are two well-known figures in the radio industry, Mr. C. G. Camp (New Zealand Employers' Federation) and Mr. P. C. Collier (Executive Member of the N.Z. Radio Manufacturers' Federation).

Both gentlemen have been associated with the radio industry since its inception in New Zealand, Mr. Camp in matters of industrial economics, and Mr. Collier, of course, besides being managing director of a large radio concern, is well known for the breadth of his vision in radio matters and his wide experience in the matter of employer-employee co-operation.

The Minister of Labour (Mr. Sullivan), when announcing the complete list of appointments to the Council, expressed his pleasure at the keenness with which the setting up of this concern had been greeted by both the employers' organizations and the Federation of Labour. The function of the Council is to make recommendtaions to the Minister on any matters likely to lead to improvements in industrial relations.

* * *

R. B. Pulham, whose appointment as Manager of G. A. Wooller and Co., Ltd., of Auckland has been announced by Mr. George A. Wooller, Managing Director. Ross Pulham, whose quiet efficiency and pleasant personality are well known to the trade, started his business career in accountancy and has been connected with the radio industry since he joined Stannage Radio in 1937. After war service with R.N.Z.A.F. in England he returned to New Zealand in 1945. He was appointed Secretary of G. A. Wooller and Co., Ltd., in 1947 and has held that position until his recent promotion.

Mr. G. C. Rowe, Production Manager of Akrad Radio Corporation, will direct the tooling up for production of Pye radio receivers at the Akrad plant. Gordon Rowe studied electrical engineering at Seddon Memorial Technical College, Auckland, and joined Radio Limited in 1930, advancing to position of assistant radio engineer. Was associated with the office of Controller of Radio Production during war-time production of radio equipment and after a short period in the Army joined Akrad late in 1945 as Production Manager. Is holder of Technical Certificate in Broadcasting and is an Associate Member of the N.Z. Electronics Institute.

* * *

Neil Avery, of H. W. Clarke (N.Z.) Ltd., is now travelling in Auckland City and the country districts of Waikato and the Bay of Plenty. Being a surf enthusiast, no doubt Neil is taking advantage of the warm climate to enjoy the northern beaches.

Les Wright recently returned from a week in Sydney with the H.M.V. Australian company, bringing news of a very satisfactory arrangement his company has just concluded with Australia concerning the exchange of production tools, thereby enabling the high cost of tooling in New Zealand to be kept within reasonable bounds.

In addition, Les reports that the production of radios in Australia shows no sign of recession, a run of 50,000 of one model being not unusual. Compared with a run of only several thousand of any one model here in New Zealand, this is truly amazing.

The continued shortage of metals, of course, will necessitate a greater use of plastic moulding for certain fittings and components.

Though enjoying the stimulation of life in Sydney, Les found the heat rather trying, the temperature some days soaring as high as 110 degrees.

British Television Convention

FULL PROGRAMME AND SUMMARIES OF SURVEY PAPERS NOW PUBLISHED

Full details are now available of the Television Convention, the "British Contribution to Television," organized by the Radio Section of the Institution of Electrical Engineers, which opens in London on Monday, April 28. It closes on the evening of Saturday, May 3.

There will be ten sessions—not nine as originally planned—and each will last approximately two hours. The opening ceremony by Lord Woolton, Lord President of the Council, and addresses by Sir John Hacking, President of the Institution of Electrical Engineers, and by Sir Noel Ashbridge, Director of Technical Services, B.B.C., will constitute the first session. Then will follow a paper on the history of television; and the other eight sessions will cover the whole field of television in its technical aspects by means of survey papers (summaries of which are now published in a booklet), supporting papers and open discussions.

(Continued on Page 47.)

New Invention by Philips

Fundamental scientific research in the Philips Research Laboratories at Eindhoven have led in the course of the last two years to the development of a new and remarkable material for permanent magnets. This was reported on 19th January last at a meeting of the Netherlands Physical Society, when G. W. Rathenau of the Philips Laboratories, speaking also on behalf of J. J. Went, E. W. Gorter, and G. W. van Oosterhout—characterized this new material as a ceramic product, with a specific gravity of about 4.8, which in structure and composition differs greatly from the traditional magnet steels. Its characteristic properties offer many new possibilities for the application of permanent magnet materials.

COMPOSITION AND PROPERTIES

If an analyst were to investigate the composition of this new magnetic material he would most probably look in the first place for cobalt and nickel, the elements which in the past have so greatly improved the quality of permanent magnets and which occur in practically all modern magnet steels. These two elements, however, are at present very scarce and expensive and it is therefore most fortunate, as well as astonishing, that they are not required at all for the manufacture of this new magnetic material.

Compared with the magnet steels hitherto used, this new product, which has been named Ferroxdure, shows very important differences. In the first place it is a ceramic material, produced by sintering or firing just like china-ware. Further, in its chemical composition it is a departure from the usual magnet steels, in that it is not a metal but an oxide, i.e., an oxygen compound. In addition to iron it contains also barium, an element never before used in any other material for permanent magnets.

FERROXDURE IS IN FACT IN EVERY RESPECT A NEW INVENTION

In contradistinction to Ferrocube—a product likewise invented by Philips—Ferroxdure is a *hard* magnetic material, which means that its magnetization is not easily destroyed. Magnetic hardness, or the coercitive force, is an essential factor for making a permanent magnet, and in Ferroxdure this factor is several times greater than that of the usual magnet steels.

The magnetic saturation of Ferroxdure is relatively low, but this drawback can be overcome by increasing the dimension of the magnet, perpendicular to the direction of magnetization, thus obtaining a large number of magnetic lines of force. Thus the shape given to the magnets is adapted to the properties of the material from which they are made. The oldest magnets, which had a very low magnetic hardness, therefore had to be made long, often in the familiar horse-shoe shape. More modern magnets (of Ticonal, Alnico and similar materials) could be made much shorter. The new Ferroxdure magnets are, in fact, so short as to resemble a flat disc or plate.

TECHNICAL SIGNIFICANCE

Considering the present scarcity of nickel and cobalt it is of great importance that in many cases Ferroxdure magnets can replace existing permanent magnets. They are already being used in the loudspeaker systems of the Philips radio receivers.

In cases where the magnet is exposed to strong demagnetizing fields these Ferroxdure magnets with their great magnetic hardness offer more possibilities than the traditional magnets, such as for use in dynamos, motors, and some special kinds of transformers. Further, with Ferroxdure magnets it appears to be possible to make a coupling replacing the usual form of mechanical coupling or gear-wheel transmission.

Being an oxide and not a metal, Ferroxdure has a low electric conductivity, in fact a billion times lower than that of iron. In many cases this is neither an advantage nor a disadvantage, but where a permanent magnet is exposed to alternating current fields, especially of high frequency, it is essential that the electrical conductivity of the material is as low as possible. In telephone, radar, and television engineering Ferroxdure will, therefore, find some very important applications.

Use is likely to be found for Ferroxdure magnets also in daily life. Toy makers will certainly find this new material most useful. Who knows whether in course of time we may not see rings of Ferroxdure used underneath plates and other tableware on board ships for holding them down on a ferromagnetic table top.

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Generally speaking, modern Receivers are of such high sensitivity, that the average listener is apt to overlook the necessity of erecting a proper aerial, and consequently does not receive the full benefit of the performance of which his set is capable.

A good Aerial increases the efficiency of any radio to a tremendous extent, not only by the improvement in reception, but also by its marked reduction in all classes of interference, that it can truly be said "A Radio is only as good as its Aerial."

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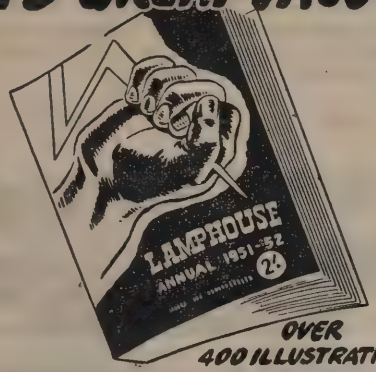

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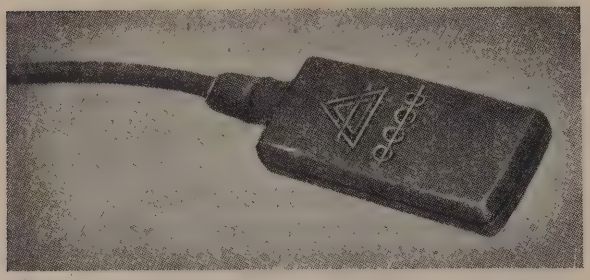
NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

This section of our paper is reserved for the introduction of new products and space preference is given to our regular advertisers. Advertising rates are charged according to space occupied. For further particulars contact Advertising Manager, R. and E., Box 8022, Wellington.

"ACOS" VIBRATION PICK-UPS



Two new vibration type pick-ups now available from the Swan Electric Co., Ltd., will be of great interest to readers.

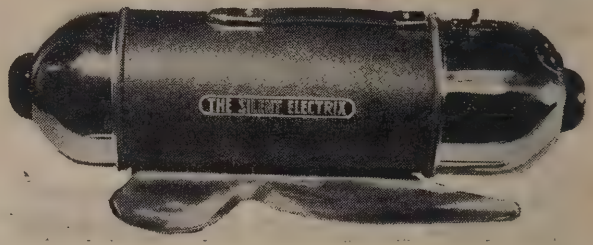
The V.P.1 Vibro-voice is a miniature vibration pick-up with a high sensitivity and an unusually wide range frequency response from 30 to 6,000 c.p.s. It has been designed for use with musical instruments particularly of the stringed type, so that their sound can be electrically amplified. The output voltage is from .05 to .1 of a volt or higher, and the size is 2 in. long by ¾ in. wide by ¼ in. thick. Construction is robust, a moulded rubber case protecting the pick-up from damage. The V.P.1 is supplied with a 20 ft. cable. This pick-up should be connected directly to the input grid circuit of the amplifier, which should have an input impedance of preferably 5 megohms.

The V.P.4 contact microphone has been specially designed for use with watch rate recorders, but can fulfil many useful functions when used in conjunction with a cathode ray oscillograph, especially of the double beam type. The V.P.4 is housed in a moulded plastic case 1.672 in. long by .734 in. wide and .312 in. thick. At one end of this case there projects a reed approximately ½ in. long for contacting the watch case or mechanism, and the cartridge is terminated in a 6 ft. shielded lead. The pick-up is a high impedance unit and should be connected directly to the input grid circuit of an amplifier, having an impedance of .5 megohms.

A NEW INSULATING TAPE

Green and Cooper Ltd., announces that stock are now available of a unique type of insulation tape branded "Parafilm," and made by Lindsay and Williams, Ltd., of Manchester, England. "Parafilm" is an amalgam of highly refined paraffin wax and pure rubber, with the addition of colouring matter, thus making it available to suit special colour featuring and matching. It is thermoplastic, non-hygroscopic, and can be used with advantage in place of ordinary insulating tape, particularly in wet situations. Heated lightly by soldering iron, match light, or other convenient method, congeals the binding into a solid mass of flexible insulation, which cannot become unwound. Servicemen, assemblers, home constructors, and others will find frequent uses for this handy roll of "Parafilm."

SILENT ELECTRIX VACUUM CLEANERS



Russell Import Co., Ltd., Wellington, proudly announce that supplies of Silent Electrix Vacuum Cleaners will shortly be available for distribution to the trade.

This well-known vacuum cleaner, which was a best seller in New Zealand until importation of vacuum cleaners was prohibited, is now manufactured under licence by Russell's associate factory, Dominion Radio and Electrical Corporation, Auckland.

The new 1952 Silent Electrix vacuum cleaner is an improved streamlined version of the former model. Operated under A.C. or D.C. mains 230/250 volts and employing 1/5th h.p. motor, the current consumption is 1.5 amperes. This new cleaner incorporates a deodorizing and air purifying system and the numerous accessories makes this an all-in-all cleaner.

Of the conventional barrel type design, the "Silent Electrix" has some improved streamlined features over earlier barrel types. Of all-steel construction, it is generously supplied with heavy chromium plate on all metal parts ensuring durability and lasting finish.

Other special features of this cleaner are: Pressure-cast aluminium runners of patented type designed for following the operator upstairs as required, an extra large easy-to-remove dust-bag, completely rubber-floated motor unit for noise-free operation, cast type swivel carpet nozzle covering a surface of 27 inches, built-in radio and television noise suppressor, foot-operated switch, treble suction-end seal, and single release-end caps.

Limited franchises are now being appointed throughout New Zealand.

H.M.V. "OXFORD" PORTABLE MODEL 525P

H.M.V. (N.Z.) Ltd.

announces the release of an exceptionally attractive and extra lightweight new A.C./battery model, retailing at £26 15s. The colour of the bakelite cabinet is at present restricted to maroon, relieved with chrome, the speaker grille of expanded aluminium being finished in cream to match the tuning knobs. Though there is a built-in

aerial, provision is also made for indoor or outdoor aerials. Weighing only 7 lb. this is one of the neatest receivers of its kind. Height, 7¾ in.; width, 9¾ in.; depth, 4½ in. The valve complement is: DF91, I.F. amplifier; DF91, R.F. amplifier; DK91, oscillator-mixer; DAF91, second detector; DL92, output. Frequency range: 500–1500 kc/sec. Batteries: C16 and 467 Minimax, 67½ volts.

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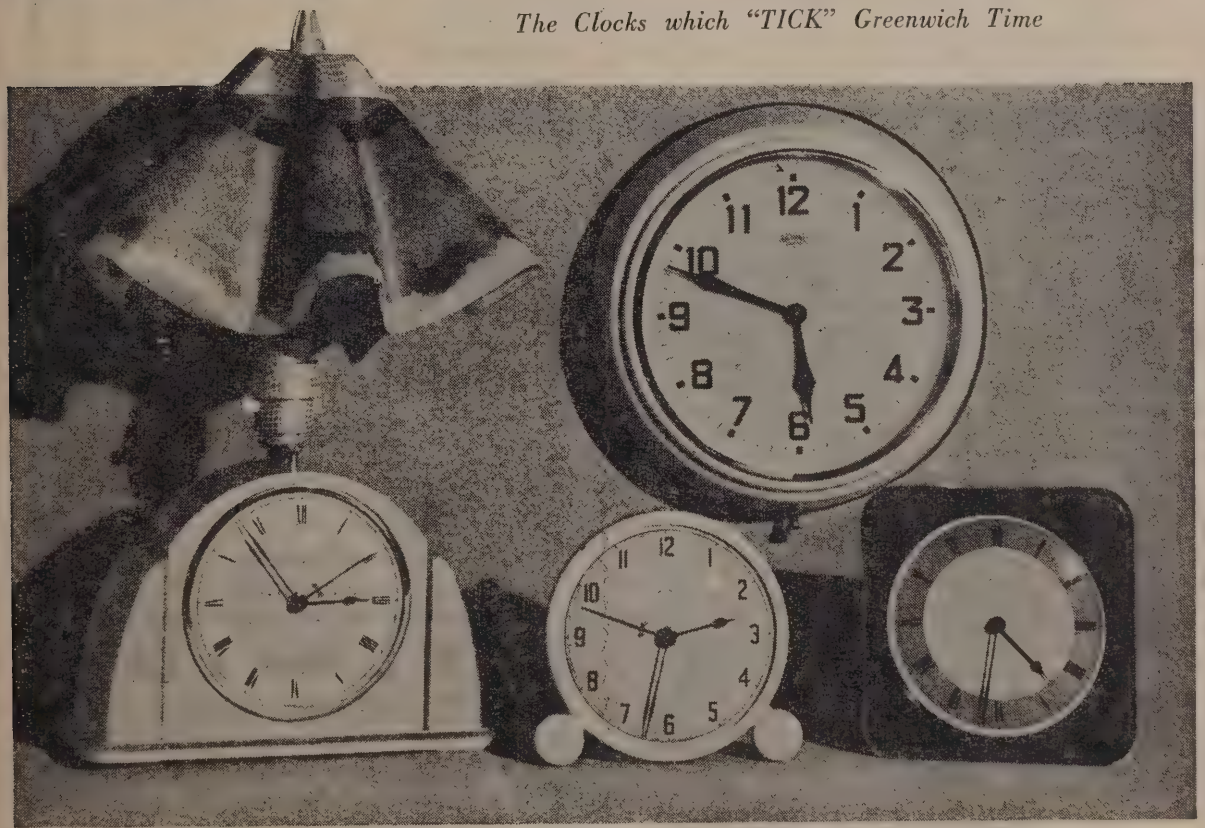

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Equalizing Crystal Pick-ups

(Continued from Page 7.)

Far from it. Competition among makes today is such that we are rapidly reaching the stage where there is no such thing as a "bad" pick-up to be bought. Some are merely better than others. It is exactly the same story as motor cars. No one would say that one of the cheaper cars today was "no good," but equally, no one would suggest that a Rolls-Royce was not better than any of them. So we hope that readers will not misinterpret these remarks, and gain the wrong impression that we do not like crystal pick-ups. There are plenty of

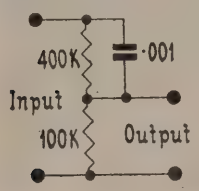

Fig. 1

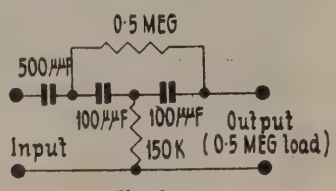

Fig. 2

These circuits refer to the response curves on the next page.

applications for which a high-priced magnetic pick-up would be a complete waste of money, besides which, the vast improvement that has resulted in all pick-ups through the advent of L/P records is not generally appreciated. In other words, a pick-up of the dual-purpose or dual-head type, which must be able to play L/P records satisfactorily, must of necessity be a much better article than many of those for which we paid far more money only a short while ago, so that one of the by-products of the L/P record has undoubtedly been an improvement all round in gramophone playing equipment, and therefore in the actual results to be had from 78 r.p.m. discs, strange as it may seem.

In spite of the above remarks on the departures that can be found in crystal pick-ups from the ideal response curve, tests carried out in our own laboratory have shown that several crystal pick-ups on the market in this country today are exceedingly easily equalized, and this, with their relatively large voltage output, makes them very easy indeed to apply. For example, where it is a case of fitting a two-speed record player to an existing radio set, a two-speed motor and one of these crystal pick-ups will give excellent results in the shape of nice clean-sounding reproduction on both 78 and L/P discs, with a minimum of installation trouble.

BASIC CRYSTAL EQUALIZER CIRCUIT

Because of the characteristic of the crystal pick-up described in an earlier paragraph, it should be clear that for 78 r.p.m. records, the equalizer circuit needs to bring up the response above 250 c/sec., which is the usual cross-over frequency. For this reason, the basic equalizer for these pick-ups has the form shown in Fig. 1.

Here R_1 and R_2 form a voltage divider, which is completely effective only at very low frequencies. This is what we want, because the pick-up is flat at frequencies below 250 cycles. The condenser C_1 then bypasses R_1 more and more, the higher the frequency, until at very high audio frequencies, the voltage divider action does not take place at all, and the full pick-up output at these frequencies is applied to the output terminal. Practically all crystal pick-ups can be made to have a reasonably flat response to 78 r.p.m. discs by the use of this circuit, with the appropriate values inserted. Since no two pick-ups are identical, what we propose to do for the user of crystals is to print in these pages a series of response curves showing the actual response obtained with particular pick-ups, and the equalizer circuits used to get those response curves. Unfortunately, it is impossible to include all the available types in the one issue, so we are making a start here with the curves for the Ronette,, type MW2, and the Acos GP20. The former has a dual-

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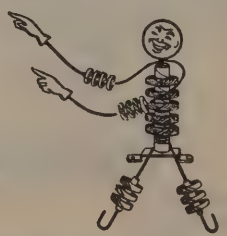
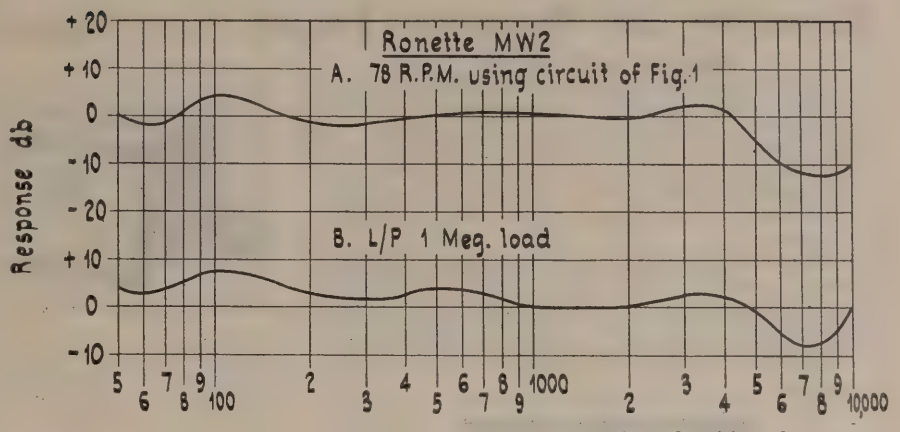
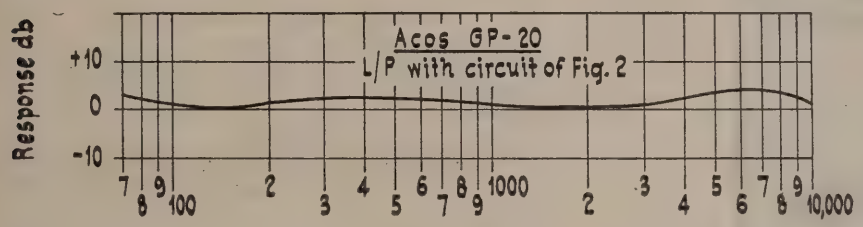


purpose stylus, so shaped that it will play either 78 or L/P records without change of the stylus. In the upper curve is shown the response obtained when the values of Fig. 1 are used, and it can be seen that a satisfactorily level response is obtained from the lowest frequencies up to 5000 c/sec., where the curve takes a roll downwards. It should be mentioned that in common with many modern crystal pick-ups that do not lay claim to being "high-fidelity" instruments, a special mechanical filter is included in the design in order to produce this dip above 5000 c/sec. Its purpose is to minimize scratch on 78 r.p.m. records, so that they will not suffer too much in this respect, by comparison with the L/P records, whose noise level is practically non-existent.





A peculiar thing about such pick-ups is that they do not sound nearly as lacking in "top" as the curve would lead one to suspect. This is probably due to the fact that the reproduction is exceptionally "clean," and because there are no sharp resonances anywhere in the working range. Indeed, until these curves were taken, using a standard frequency record, it was difficult to believe, by listening to the pick-up on music, that this drop above 5000 c/sec. was there at all, although the makers' literature gives the useful range as from 70 to 5,000 c/sec. Actually, the output above this frequency is by no means negligible, and this probably helps to account for the fact that the drop is hard to detect in practice. It would be easily enough spotted in direct comparison with a high-fidelity pick-up, but the writer is convinced that this would be the only way of demonstrating it.

NO EQUALIZATION AT ALL FOR L/P

As readers will all be aware by now, the recorded response of L/P discs is entirely different in character from that of 78 r.p.m. records. Indeed, it turns out that L/P records might have been made with the express idea of suiting the response curve of crystal pick-ups so well that no equalizer circuit is needed.

This comes about because the overall response curve of L/P records is fairly close to being a simple constant-amplitude one from the highest to the lowest recorded frequencies; it is therefore to be expected that a crystal unit whose response approaches the theoretical fairly closely should be able to play L/P records without equalization. In practice, how well this turns out is shown by the lower curve for the Ronette MW2.

As an example of a crystal pick-up which does need equalization for L/P records, we have shown the L/P response of the Acos GP20 L/P head, as achieved through the use of a quite elaborate equalizer circuit. In this case, the simple basic crystal type would hardly give the required answer. This pick-up, it can be seen, has an extended frequency response, so that for ordinary radio sets, whose audio response is not up to it, the first type would seem more suitable, the second being reserved for use with high-quality amplifiers with very low distortion and extended frequency range. Next month it is hoped to print curves and equalizer circuits relating to some of the Philips range of crystal heads, as used on this firm's automatic changers and record players.

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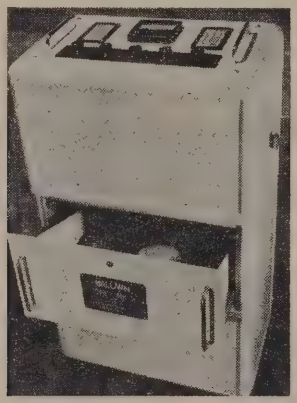
MEASURING RAYS

The growing use of radio-active substances in hospitals in connection with treatment by gamma, alpha, and beta rays and X-rays, makes necessary the provision of ionization meters for measuring these rays. Radio-active isotopes are frequently used for checking blood circulation, particularly where there is disease of the veins, for affections of the thyroid gland, and for locating brain tumours.

Treatment by radiation can be accurately controlled by these meters, and some of them will be on show at the Scientific and Optical Instruments Section of the British Industries Fair (Earls Court and Olympia, London, and Castle Bromwich, Birmingham, May 5 to 16). The device also prevents over-exposure of hospital staffs to radiation.



A meter for measuring radio-active rays which will control medical treatment by radiation. This meter, made by Baldwin Instruments Company, Limited, of Dartford, Kent, England, will be on view at the British Industries Fair (Earls Court and Olympia. London, and Castle Bromwich, Birmingham, May 5 to 16).

The instrument is also valuable in checking "stray" radiations which often arise during treatment with X-rays and radio-active substances, and thus provides an extra check for both patients and staffs. Additional chambers for the instruments can detect stray X-rays and gamma rays, soft X-rays, alpha and beta rays and radium needles.

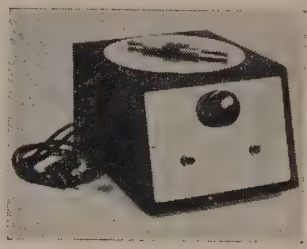
* * *

MIXING BY MAGNETISM

The stirring of bottles in laboratories was a dull job until electric stirring machines came into use. But they had one difficulty: the stirring apparatus prevented easy access to the liquid being stirred during the process.

Now magnetic stirrers are being marketed. In these the vessel containing the liquid is placed on a magnetic base; in the vessel a stirrer bar revolves at the bottom at a speed which can be varied and controlled. The pathologist can add to the contents of the vessel while stirring is in progress.

This apparatus will be on view at the Scientific and Optical Instruments Section of the British Industries Fair (Earls Court and Olympia, London, and Castle Bromwich, Birmingham, May 5 to 16). Several sizes of stirrer bars, for different types of liquids will be shown with the machine.



This machine, for use in laboratories, stirs liquids. It is operated by magnetism, and will be on show at the British Industries Fair (Earls Court and Olympia, London, and Castle Bromwich, Birmingham, May 5 to 16). Makers: Apis Engineering and Research Limited, of 136

This type of stirrer can be used when liquids have to be stirred under pressure or in a vacuum for there is no need of any external connection to the stirrer bar.

* * *

NEWER GALVANOMETERS

A doctor taking a recording on an encephalograph of the workings of the human brain makes use of a galvanometer, an instrument for recording minute electric currents.

Should he want to chart the heart beats of a patient on a cardiograph, the galvanometer will help him. The cardiograph may show a "murmur" in the heart, which might indicate the early stages of a heart disease. From the graph the doctor can even diagnose the disease and begin early treatment.

The newest type of galvanometer (which has many uses in industry and science) will be on show at the Scientific and Optical Instruments Section of the British Industries Fair (Earls Court and Olympia, London and Castle Bromwich, Birmingham, May 5 to 16). These new instruments are five times as sensitive as earlier instruments and 25 per cent. more accurate.

For medical puropses the galvanometer is used in conjunction with a chart on which a time base is marked off in three-thousandth parts of a second.

PRACTICAL RADIO COURSE

Representing a new step in basic radio training, the Australian Radio College have introduced a new practical radio course, in which the student learns largely by using radio components and conducting experiments.

To avoid wastage of components, the course has been carefully planned so that the components are ultimately assembled into a complete radio test panel suitable for service work...

The parts for the test panel are sorted into nine separate kits and issued in a sequence which enables hundreds of interesting practical experiments to be performed.

As many students are situated in outback areas or overseas, where power mains are not always available, the equipment is designed to operate from batteries which are included in the kits but, where required an A.C. power unit can be substituted for the batteries.

On completion of the various experiments the parts are assembled on to the main panel provided to form a complete kit of service instruments comprising a multimeter, modulated oscillator and signal tracer which is really professional in appearance and performance and which costs far less than equivalent commercial instruments.

The Practical Instruction Course provides an opportunity for students to gain practical experience in keeping with their theoretical studies and it is also available to servicemen and hobbyists who already have some knowledge of fundamentals and wish to purchase the series of kits only.

100-Watt Final With a 12/6 Tube

Shown in the cover photograph is a final amplifier stage built round one of the "micro-pup" valves currently available on the surplus market for the ridiculous sum of 12s. 6d. These valves have an interesting background, in that they were originally used in A.S.V. radar transmitters working on about 175 mc/sec. Unlike most tubes specially designed for pulse work in radar transmitters, these ones, whose Service designation was VT90 (British numbering) have ratings that allow them to be used on C.W. From the amateur point of view, their main disadvantage is that the filament requires a great deal of heating power—55 watts, to be exact—according to the ratings, but it is quite possible that since C.W. does not call for the tremendous peak emission that pulse working does, it might be possible to work them on reduced filament voltage. In any case, anyone who has an old transformer core rated at 50 watts or so can easily wind a filament transformer to deliver the required 8.5 volts at 7 amps or so.

The unit shown was built in the "R. and E." laboratory in order to show that it is a practical proposition to use these tubes in an amateur transmitter. It has band-switching input circuit, and plug-in coils for the plate circuit, and is plate-neutralized in the conventional manner. Only the layout of the circuit is out of the ordinary, for the valve was originally intended to be used with co-axial or parallel-rod transmission-line circuits. The prototype will be for sale when our laboratory has finished with it.

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Leaflet TR-7B—New Series of Precision Coaxial Connectors: Transradio Ltd., England.

"Pope" Receiving Tube Manual. (Swan Electrical Co. Ltd.).

"Long Playing," Full Frequency Range Records: The Decca Record Co. Ltd., England (H.M.V. (N.Z.) Ltd.).

Brochure "Convention on the Brtiish Contribution to Television ,(1952)": The Institution of Electrical Engineers, Radio Section, London.

"Transmitting Valves" by J. P. Heyboer and P. Zijlstra: Philips Technical Library, N.V. Philips Gloeilampenfabrieken, Eindhoven, Nederland.

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"Radiotronics," February, 1952: Amalgamated Wireless Valve Co., Pty., Ltd.

The Scanner, September/October, 1951: Decca Radar Ltd. (Eng.) (Electronic Navigation Ltd.)

British TV Convention

(Continued from Page 39.)

for discussion on all the papers—more than 60.

Under-water television will be dealt with in the paper given at the seventh session on "Industrial Television." Historically Britain has done vitally important pioneer work in industrial, no less than in broadcasting, television; and the seventh session paper will review the various applications of television technique which fall outside the field of broadcasting.

Other papers will be: the engineering technique of programme origination; television broadcasting stations; a survey of British research on wave propagation with particular reference to television; point-to-point transmission; receiving equipment; and television as a communications problem, with especial reference to the conservation of ether space.

As a practical counterpart to the papers will be a series of visits. The Radio and Television Show in Manchester is being held from April 23 to May 3, and the Institution of Electrical Engineers will, on behalf of the Radio Industry Council, issue tickets (price 2s.) to registered members of the Convention who wish to attend.

There will be visits too to the B.B.C. television studios, to the Post Office Research Station, to the terminal of the London-Birmingham television link (the Museum Telephone Exchange) and to the premises of a number of manufacturers of television equipment.

Members of the Convention will also be able to visit the B.B.C. transmitting stations at Sutton Coldfield, near Birmingham, and at Holme Moss, between Huddersfield and Manchester, the most powerful transmitter in the world.

Among the social functions which have been arranged for the Convention is the Television Ball and Dinner at Grosvenor House, Park Lane, London, on Friday, May 2.

Complete proceedings of the Convention, containing the addresses, the full text of all the papers and reports of the discussions, will be published in four issues of a special volume of the "Proceedings" of the Institution.

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N.Z.E.I. Proceedings

(Continued from Page 33.)

insulation, and with high-voltage insulation in power supplies, etc. The use of single sideband transmission, with the same peak output as an A.M. transmitter results in a 9 db. gain in effective signal strength, so that without increasing peak powers or voltages at all, single sideband enables this 9 db. improvement to be obtained.

The speaker went on to describe the transmitting and receiving arrangements used in one of the experimental equipments built at R.A.E. and explained the mode of action of the automatic frequency control for the receiving carrier oscillator.

A most interesting lecture was followed by a lively session devoted to questions, which were answered by the speaker, after which the chairman, Mr. Dippy, proposed a vote of thanks to Mr. Browne, and this was carried by acclamation.

Tube Data

(Continued from Page 27.)

the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the R.F. exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits and of cancelling the even-order harmonics from the output. If parasitic oscillations occur in the parallel or the push-pull circuits, they can often be eliminated by connecting a non-inductive resistor of 10 to 100 ohms in series with each grid lead, as close to the tube as possible.

Photo-electric Cells

(Continued from Page 30.)

light is interrupted and the machinery is stopped by an photo-conductive cell will pass sufficient current to operate a very sensitive relay directly. A relay having a winding resistance of 5000 to 10,000 ohms is frequently used in connection with these cells. When an amplifier is used with photo-conductive cells, the choice of the grid resistance should depend upon the light resistance of the particular cell used, rather than being as high as possible, as with photo-tubes.

Fig. 7 illustrates the novel use of a self-generating selenium cell with a 1N34 germanium crystal rectifier to operate a rugged, less expensive relay. A small D.C. operating bias is provided by the crystal rectifier operated from the 6.3 volt winding of the filament transformer. This circuit is applicable to a wide variety of devices such as intrusion alarms, light-operated switches, garage door openers, etc. It is also used frequently in crowd-attracting window displays because of its simplicity and the fact that the absence of a high gain amplifier makes it immune to false operation by extraneous signals.

PHOTO-VOLTAIC CELLS

Photo-voltaic cells are most frequently used directly in series with a relay, meter, or other load. See Fig. 8. A simple photo-voltaic cell consists of a lead electrode and an oxidized copper electrode immersed in an electrolyte. Exposure to light causes the cell to become a generator. Other "dry" photo-voltaic cells consist of a sandwich of iron and selenium fitted with copper electrodes. Since such cells generate an E.M.F., they require no external source of power. The copper oxide type of cell (Photox) has a colour response almost identical with that of the human eye and hence is used in illumination control and in regulating industrial processes in which colour or change of colour of the product are important.

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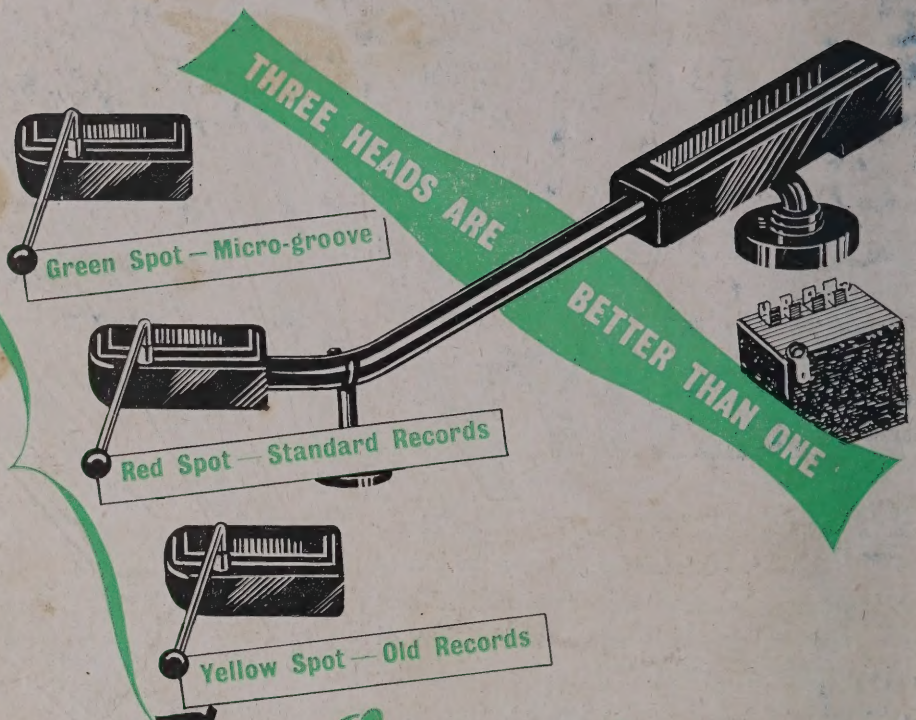

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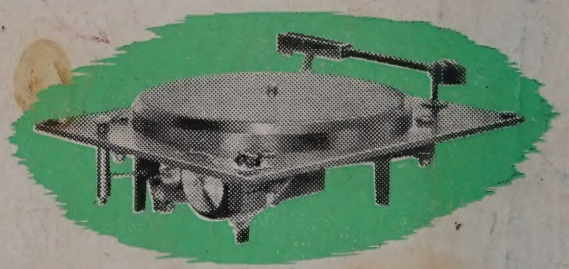

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